85-5158

NO SPEC

UNIVERSAL CONTROLS
CHESAPEAKE VA PHONE 420-4672
Robertshaw LICENSEE
85-5158

UNIVERSAL CONTROLS
Commercial, Industrial Control Systems

OPERATION & MAINTENANCE MANUAL

FOR

MECHANICS TRAINING FACILITY

CAMP LEJEUNE, NORTH CAROLINA

CONTRACT #N62470-85-5158

SECTION 15971

JOB #18015

GENERAL CONTRACTOR: J.W. COOK & SON, INC.
HIGHWAY 701 NORTH
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SECTIONAL INDEX

TAB 1.4.1 MATERIAL CUTSHEETS WITH
a. GENERAL DESCRIPTION & SPECIFICATIONS
b. INSTALLATION & CHECKOUT PROCEDURES
c. ELECTRICAL DESCRIPTION
e. CALIBRATION PROCEDURES
f. PREVENTIVE MAINTENANCE REQUIREMENTS
h. PARTS LIST
i. INTERFACE REQUIREMENTS

TAB 1.4.2 d. TROUBLE SHOOTING TEST PLAN
k. SEQUENCE OF OPERATION, SCHEDULES AS BUILT DRAWINGS

TAB 1.4.6 PERSONNEL TRAINING AND TOOL REQUIREMENTS

1.2.1a SAFETY PRE-CAUTIONS

CONTROL PANELS:

PANELS CONTAIN 120 VOLT POWER WHICH IS AN ELECTRIC SHOCK HAZARD.

STARTERS & DISCONNECT:

THESE ITEMS CONTAIN LINE VOLTAGE FROM 480 VOLTS TO 120 VOLTS WHICH IS AN ELECTRIC SHOCK HAZARD.

1.2.1b OPERATOR PRE-START

MAKE-UP AIR UNITS:

A. VERIFY PROPER MAIN AIR PRESSURE (20#PSI)
B. VERIFY PROPER VOLTAGES AT UNIT STARTER AND PANEL

VAV BOXES:

A. VERIFY PROPER MAIN AIR PRESSURE (20#PSI)
B. VERIFY PROPER VOLTAGE AT UNIT FAN SWITCH

TIME CLOCK CONTROL PANEL:

A. CHECK FOR 120 VOLTS INCOMING IN PANEL
B. CHECK TIME CLOCK PROGRAMMING

1.2.1c START-UP, SHUTDOWN AND POST SHUTDOWN PROCEDURES

MAKE-UP UNITS:

START-UP - PLACE STARTER SWITCH IN AUTO POSITION, ENERGIZE AN ASSOCIATED EXHAUST FAN AND UNIT WILL START.

SHUTDOWN - DE-ENERGIZE AN ASSOCIATED EXHAUST FAN AND UNIT WILL STOP.

POST SHUTDOWN - NOT APPLICABLE

TIMECLOCK PANEL:

START-UP - PROGRAM TIMECLOCK FOR START TIMES AND STOP TIMES AFTER ENERGIZING CONTROL CIRCUIT BREAKER.

SHUTDOWN - DE-ENERGIZE CONTROL CIRCUIT BREAKER.

POST SHUTDOWN - PLACE TIMECLOCKS IN THE UNOCCUPIED MODE.

1.2.1d NORMAL OPERATIONS

1. SEE SEQUENCE OF OPERATION, TAB SECTION 1.4.2
2. SEE CONTROL DIAGRAMS ATTACHED

1.2.1e EMERGENCY OPERATIONS

1. IF TIMECLOCK FAILS:

HEATING ALTERNATE: a. RAISE NITE THERMOSTAT ABOVE NORMAL OPERATING TEMPERATURES. THIS WILL BRING SYSTEM VAV BOXES BACK ON LINE FOR HEAT.

HEATING OR COOLING ALTERNATE b. PLACE WIRE JUMPERS ACROSS TIMECLOCK CONTACTS WHICH WILL BRING ON ROOFTOP UNITS AND ASSOCIATED VAV BOXES.

c. PUSH CIRCUIT BYPASS SWITCH ON TIMECLOCK.

2. EMERGENCY SHUTDOWN:

a. TURN OFF ALL CIRCUITS TO HVAC EQUIPMENT AT POWER PANELS.

1.2.1f OPERATOR SERVICE REQUIREMENTS

SEE ROBERTSHAW MAINTENANCE REQUIREMENT TAB SECTION 1.4.2.

1.2.1g ENVIRONMENTAL CONDITIONS

SEE CUTSHEETS ON EACH INDIVIDUAL CONTROL TAB SECTION 1.4.1.

1.2.2 PREVENTIVE MAINTENANCE

1.2.2.1 NOT APPLICABLE
1.2.2.2 PLAN AND SCHEDULE
SEE ROBERTSHAW MAINTENANCE REQUIREMENT
TAB SECTION 1.4.2

1.2.3 CORRECTIVE MAINTENANCE

1.2.3.1 TROUBLE SHOOTING GUIDE
SEE TROUBLE SHOOTING TEST PLAN
TAB SECTION 1.4.2.

1.2.3.2 SEE ATTACHED CONTROL DIAGRAMS

1.2.3.3 SEE MATERIAL CALIBRATION CUTSHEETS TAB SECTION 1.4.1
ON INDIVIDUAL CONTROLS
TOOLS REQUIRED: THERMOMETER, ALLEN WRENCHES.

SCREW DRIVERS AND PRESSURE GAUGES

1.2.3.4 SEE CUTSHEETS ON INSTALLATION GUIDES FOR EACH INDIVIDUAL CONTROL IN TAB SECTION 1.4.1.
TOOLS REQUIRED: SCREW DRIVERS

1.2.3.5 SPARE PARTS & SUPPLIES
SEE MATERIAL LIST AND CUTSHEETS FOR ACCESSORIES TAB SECTION 1.4.1.

1.2.3.6 CORRECTIVE MAINTENANCE
SEE ROBERTSHAW MAINTENANCE REQUIREMENTS
TAB SECTION 1.4.2.

1.2.4.1 PARTS IDENTIFICATION
USE CONTROL DRAWINGS TO IDENTIFY ALL PART NUMBERS THEN USE MATERIAL LIST IN TAB SECTION 1.4.1 TO LOCATE CUTSHEET ON PART FOR FURTHER INFORMATION ON ACCESSORIES OR HOW TO REPLACE.

WARRANTY INFORMATION

1.2.4.2 ALL CONTROLS ARE WARRANTEED FOR ONE YEAR PROVIDED THE MAINTENANCE REQUIREMENTS REQUIREMENTS ARE FOLLOWED AS INDICATED IN TAB SECTION 1.4.2

PERSONNEL TRAINING

1.2.4.3-
} SEE TAB SECTION 1.4.6
1.2.4.4-

TAB PLACEMENT HERE

DESCRIPTION:

1.4.1

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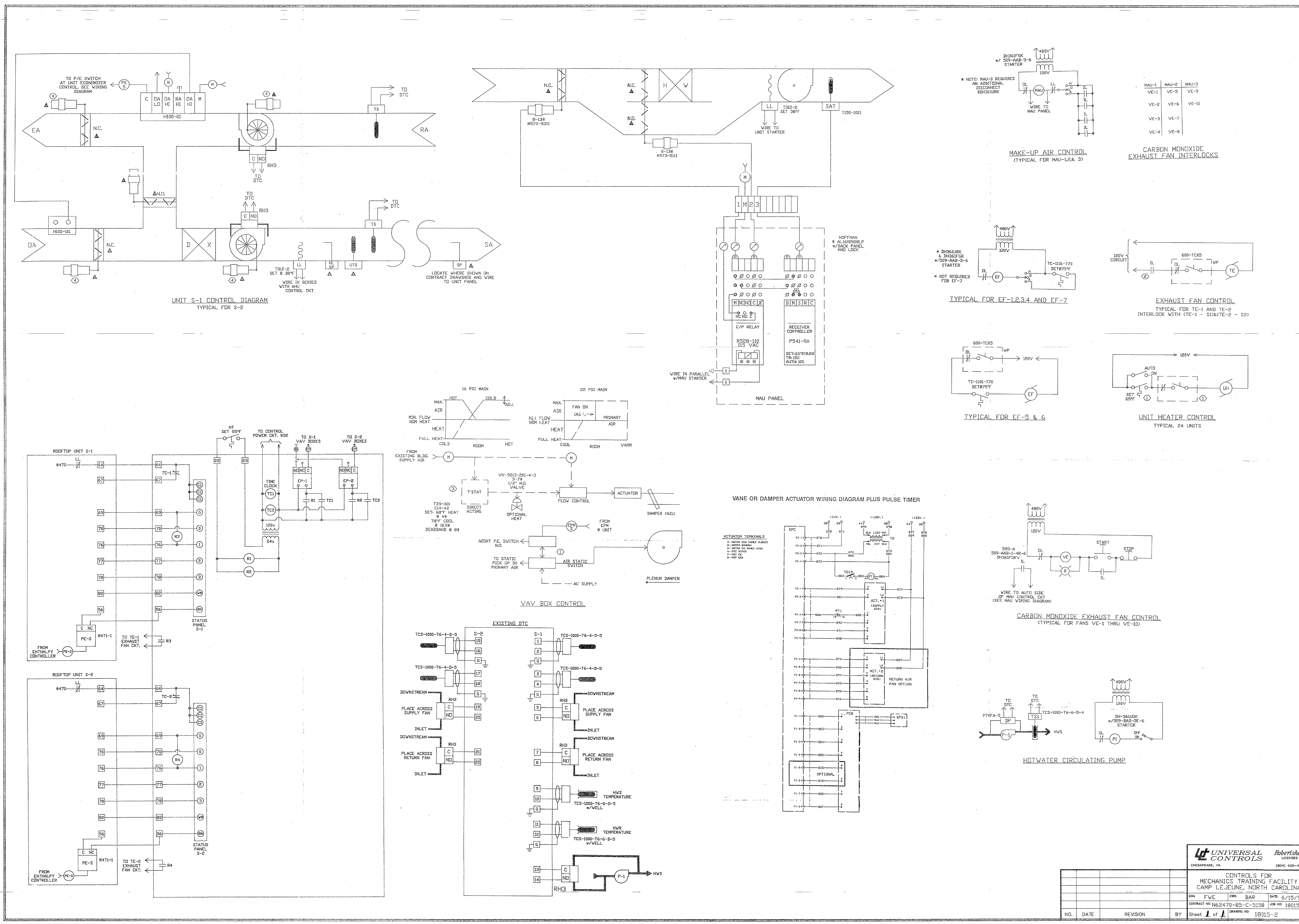
1.4.1


UNIT S-1 CONTROL DIAGRAM
TYPICAL FOR S-2
MAKE-UP AIR CONTROL
(TYPICAL FOR MAU-1,2,& 3)
CARBON MONOXIDE EXHAUST FAN INTERLOCKS
MAU PANEL
TYPICAL FOR EF-1,2,3,4 AND EF-7
EXHAUST FAN CONTROL
TYPICAL FOR TE-1 AND TE-2
TYPICAL FOR EF-5 & 6
UNIT HEATER CONTROL
TYPICAL 24 UNITS
VAV BOX CONTROL
VANE OR DAMPER ACTUATOR WIRING DIAGRAM PLUS PULSE TIMER
CARBON MONOXIDE EXHAUST FAN CONTROL
(TYPICAL FOR FANS VE-1 THRU VE-10)
HOTWATER CIRCULATING PUMP
ROOFTOP UNIT S-1
ROOFTOP UNIT S-2
EXISTING DTC
UNIVERSAL CONTROLS
CHESAPEAKE, VA
Robertshaw LICENSEE
(804) 420-4672
CONTROLS FOR MECHANICS TRAINING FACILITY CAMP LEJEUNE, NORTH CAROLINA
ENG. FWE
DWN. BAR
DATE 6/15/90
CONTRACT NO. N62470-85-C-5158
JOB NO. 18015
Sheet 1 of 1
DRAWING NO. 18015-2
NO. DATE REVISION BY

85-5158

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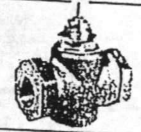
SECTION 1.4.1
SUBMITTAL FOR 15971
MATERIAL LIST

QTY	SUBMITTAL PARA	SUPPLIER	PART NO.	DESCRIPTION	MANUFACTURER	PAGE
19	1.4.1.A	UNIVERSAL CONTROLS	VK-9213-201-4-3	VALVES	ROBERTSHAW	1
3	1.4.1.A	UNIVERSAL CONTROLS	M572-5311	ACTUATOR	ROBERTSHAW	3
3	1.4.1.A	UNIVERSAL CONTROLS	M573-5111	ACTUATOR	ROBERTSHAW	3
3	1.4.1.B	UNIVERSAL CONTROLS	P541-RA	REC. CONTROLLER	ROBERTSHAW	5
3	1.4.1.C	UNIVERSAL CONTROLS	T150-1021	TEMP. TRANSMITTER	ROBERTSHAW	7
2	1.4.1.C	UNIVERSAL CONTROLS	TCS-1000-T6-4-D-5	TEMP. SENSORS	TEMP. CONTROL SPEC.	8
1	1.4.1.C	UNIVERSAL CONTROLS	TCS-1000-T6-6-D-5	TEMP. SENSORS	TEMP. CONTROL SPEC.	8
	1.4.1.D	NOT USED				
	1.4.1.E	NOT USED				
2	1.4.1.F	UNIVERSAL CONTROLS	H100-01	ENTHALPY CONT.	ROBERTSHAW	11
2	1.4.1.G	UNIVERSAL CONTROLS	225B-111CA	E/P RELAY	MAC	12
3	1.4.1.G	UNIVERSAL CONTROLS	R528-110	E/P RELAY	ROBERTSHAW	14
2	1.4.1.G	UNIVERSAL CONTROLS	R471-1	P/E RELAY	ROBERTSHAW	15
1	1.4.1.G	UNIVERSAL CONTROLS	P74FA-5	DIFF. PRESS. SW	PENN	16
2	1.4.1.G	UNIVERSAL CONTROLS	RH-3	DIFF. PRESS. SW	COLUMBUS ELECTRIC	17
2	1.4.1.G	UNIVERSAL CONTROLS	P-125-1-3	RELAY	ROBERTSHAW	18
2	1.4.1.H	UNIVERSAL CONTROLS	2A516	TIME CLOCK	PARAGON	19

3	1.4.1.I	UNIVERSAL CONTROLS	AL16H2008LP	ENCLOSURE	HOFFMAN	20
5		UNIVERSAL CONTROLS	TC-5141	LOW LIMIT	ROBERTSHAW	21
16		UNIVERSAL CONTROLS	T35-301	THERMOSTAT	ROBERTSHAW	22
16		UNIVERSAL CONTROLS	C14-42	COVER	ROBERTSHAW	23
7			TC-1101-770	THERMOSTAT	ROBERTSHAW	24
2			TC-1102-770	THERMOSTAT	ROBERTSHAW	24

2-WAY VALVES, SCREWED (1/2" TO 3"), UNION SWEAT (1/2" TO 2") AND FLANGED (2-1/2" TO 6") WITH PNEUMATIC ACTUATORS

TABLE 1. Select Valve Body including P Code (Valve Size, Cv Rating, Port Code) or select Valve Assembly with correct Input Signal (See Table 2 also) less Actuator Code (XXX) including the P Code (Size, Cv Rating, Port Code). (See Pages 298-302 for Valve Sizing.)




			APPLICATION				
			Chilled or Hot Water 280°F Max. 35 psig Steam			Hot Water 300°F Max. 100 psig Steam	Hot Water 366°F Max. 150 psig Steam
			Screwed	Union Sweat	Flanged	Screwed	
Size			1/2"—3"	1/2"—2"	2-1/2"—6"	1/2"—2"	1/2"—2"
Normally Open Valves	Valve Body		VB-9213-0-4-P	VB-9214-0-4-P	VB-9213-0-5-P	VB-9253-0-4-P	VB-9273-0-4-P
	Valve Assembly Pneumatic		VK-9213-XXX-4-P	VK-9214-XXX-4-P	VK-9213-XXX-5-P	VK-9253-XXX-4-P	VK-9273-XXX-4-P
	Valve Assembly Pneumatic w/Positive Positioner		VK4-9213-XX1-4-P	VK4-9214-XX1-4-P	VK4-9213-XX1-5-P	VK4-9253-XX1-4-P	VK4-9273-XX1-4-P
Normally Closed Valves	Valve Body		VB-9223-0-4-P	VB-9224-0-4-P	VB-9223-0-5-P	VB-9263-0-4-P	VB-9283-0-4-P
	Valve Assembly Pneumatic		VK-9223-XXX-4-P	VK-9224-XXX-4-P	VK-9223-XXX-5-P	VK-9263-XXX-4-P	VK-9283-XXX-4-P
	Valve Assembly Pneumatic w/Positive Positioner		VK4-9223-XX3-4-P	VK4-9224-XX3-4-P	VK4-9223-XX3-5-P	VK4-9263-XX3-4-P	VK4-9283-XX3-4-P
Flow Type			Equal %	Equal %	Equal %	Equal %	Equal %
Material	Body		Bronze	Bronze	Cast Iron	Bronze	Bronze
	Seat		Bronze	Bronze	Bronze	Stainless Steel	Stainless Steel
	Stem		Stainless Steel	Stainless Steel	Stainless Steel	Stainless Steel	Stainless Steel
	Plug		Brass	Brass	Brass	Stainless Steel	Stainless STeel
	Packing		Spring Loaded Teflon Cone	Spring Loaded Teflon Cone	Spring Loaded Teflon Cone	Spring Loaded Teflon Cone	Spring Loaded Teflon Cone
	Disc		Composition	Composition	Composition	Teflon	None
STEAM							
Pressure (psig)	Static		250	250	125	250	250
	Inlet		35	35	35	100	150
	Recom. Diff.*		20	20	20	35	50
Fluid Temp. °F (°C)	Max.		281 (138)	281 (138)	281 (138)	340 (171)	366 (180)
WATER							
Pressure (psig)	Static		250	250	125	250	250
	Recom. Diff.*		35	35	35	35	50
Fluid Temp. °F (°C)	Min.		40 (4)	40 (4)	40 (4)	40 (4)	40 (4)
	Max.		281 (138)	281 (138)	281 (138)	300 (149)	366 (180)

NOTE: These charts are color coded as shown below to assist valve selection. Note it is possible to select either a valve assembly or component parts (actuator, valve linkage, valve body).

ORDERING EXAMPLES

1. Valve Assembly: VK4-9213-601-4-11
2. Valve Body: VB-9213-0-4-11

   Actuator: MK-6801

   Linkage: AV-430

   Positive Positioner: AK-42309-500

- Valve Body Data less P Code (Size, Cv Rating, Port Code) or Valve Assembly less Actuator Code (XXX) and less P Code (Size, Cv Rating, Port Code)
- P Code (Size, Cv Rating, Port Code)
- Actuator or Actuator Code (XXX) for Valve Assemblies
- Valve Linkage

TO SELECT A PORT CODE (P)

P Code	Valve Size†	Cv				
-1	1/2"	0.4	0.4		0.4	0.4
-2		1.3	1.3		1.3	1.3
-3		2.2	2.2		2.2	2.2
-4		3.6	3.6		3.6	3.6
-5	3/4"	5.0	5.0		5.0	5.0
-6		6.2	6.2		6.2	6.2
-7	1"	8.2	8.2		8.2	8.2
-8		11.0	11.0		11.0	11.0
-9	1-1/4"	16.0	16.0		16.0	16.0
-10	1-1/2"	25.0	25.0		25.0	25.0
-11	2"	40.0	40.0		40.0	40.0
-12	2-1/2"	65		56		
-13	3"	85		85		
-14	4"			145		
-15	5"			235		
-16	6"			350		

* Maximum recommended differential pressure in full open position. Do not exceed recommended differential pressure (pressure drop) or integrity of parts may be affected.
NOTE: Do not exceed close-off rating.
† Valve size refers to NPT on globe valves or nominal I.D. of copper tubing for union sweat valves.
CAUTION: Solder, tubing and/or pipe schedules must meet or exceed working static pressure requirements.

VALVES

ITEM NO. 2
SUBMITTAL PARA. 1.4.1.A
PRODUCT PARA. 2.1.2

/

2-WAY VALVES, SCREWED (1/2" TO 3"), UNION SWEAT (1/2" TO 2") AND FLANGED (2-1/2" TO 6") WITH PNEUMATIC ACTUATORS

TABLE 2. 1/2"—2" Valves, select **Actuator** or **Actuator Code (XXX)** with correct Input Signal having sufficient close-off for the application. If selecting Component Parts, select **Valve Linkage** and **Positive Positioner** if required.




Effective Area	6 Sq. In.			11 Sq. In.			11 Sq. In.			50 Sq. In.		
Valve Linkage	AV-400			AV-401			AV-420			AV-430		
Positive Positioner	AK-42309-500			AK-42309-500			AK-42309-500			AK-42309-500		
Factory Available Assembly with Positive Positioner — N.O. Valves	Yes	No	No	Yes	No	No	Yes	No	No	Yes	No	No
Factory Available Assembly with Positive Positioner — N.C. Valves	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
Actuator Code (XXX)	201	202	203	301	302	303	371	372	373	601	602	603
Actuator	MK-2690			MK-4601	MK-4611	MK-4621	MK-4801	MK-4811	MK-4821	MK-6801	MK-6811	MK-6821
Spring Range (psig)	3-7	5-10	8-13	3-6	5-10	10-13	3-8	5-10	8-13	3-8	5-10	8-13

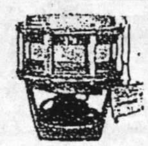
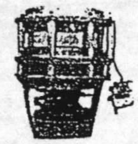
CLOSE-OFF PRESSURE RATING†

Normal Position	Factory Available Valve Assemblies	Valve Body	P Code	Size	Supply Air Pressure (psig) 15	20	15	20	15	20	Supply Air Pressure (psig) 15	20	15	20	15	20	Supply Air Pressure (psig) 15	20	15	20	15	20	Supply Air Pressure (psig) 15	20	15	20	15	20
Normally Open	VK-9213-XXX-4-P VK4-9213-XX1-4-P VK-9214-XXX-4-P VK4-9214-XX1-4-P VK-9253-XXX-4-P* VK4-9253-XX1-4-P* VK-9273-XXX-4-P* VK4-9273-XX1-4-P*	VB-9213-0-4-P VB-9214-0-4-P VB-9253-0-4-P VB-9273-0-4-P	-1-2-3-4	1/2"	170	250	90	220		140	250	250	180	250	35	250												
			-5-6	3/4"	75	130	40	95		60	180	250	80	180	15	120												
			-7-8	1"	40	75	20	55		35	100	165	40	100	5	65												
			-9	1-1/4"	25	45	10	35		20	60	100	25	60		40												
			-10	1-1/2"													25	55	15	40		25	160	250	115	230	30	160
			-11	2"													20	30	10	20		10	90	160	60	125	15	90
Normally Open	VK-9223-XXX-4-P VK4-9223-XX3-4-P VK-9224-XXX-4-P VK4-9224-XX1-4-P VK-9263-XXX-4-P* VK4-9263-XX3-4-P* VK-9283-XXX-4-P* VK4-9283-XX3-4-P*	VB-9223-0-4-P VB-9224-0-4-P VB-9263-0-4-P VB-9283-0-4-P	-1-2-3-4	1/2"	15		110		180		60		180		250													
			-5-6	3/4"			40		70		15		65		180													
			-7-8	1"			20		35		5		30		100													
			-9	1-1/4"			10		20				15		60													
			-10	1-1/2"															5		25		40		85		170	
			-11	2"																	10		20		50		65	

*Not available with MK-2690's.

†Close-off pressure ratings apply when valves are installed with pressure under the seat.

TABLE 2. 2-1/2"—6" Valves, select **Actuator** or **Actuator Code (XXX)** with correct Input Signal having sufficient close-off for the application. If selecting Component Parts, select **Valve Linkage** and **Positive Positioner** if required.

Effective Area	50 Sq. In.			100 Sq. In.			100 Sq. In.		
Valve Linkage	AV-495			AV-496			AV-496		
Positive Positioner	AK-42309-500			AK-42309-500			AK-42309-500		
Factory Available Assembly with Positive Positioner — N.O. Valves	Yes	No	No	Yes	No	No	Yes	No	No
Factory Available Assembly with Positive Positioner — N.C. Valves	No	No	Yes	No	No	Yes	No	No	Yes
Actuator Code (XXX)	601	602	603	801	—	803	811	—	813
Actuator	MK-6801	MK-6811	MK-6821	MK-8801	MK-8811	MK-8821	MK-8901	MK-8911	MK-8921
Spring Range (psig)	3-8	5-10	8-13	3-8	5-10	8-13	3-8	5-10	8-13

CLOSE-OFF PRESSURE RATING†

Normal Position	Factory Available Valve Assemblies	Valve Body	P Code	Size	Supply Air Pressure (psig) 15	20	15	20	15	20	Supply Air Pressure (psig) 15	20	15	20	15	20	Supply Air Pressure (psig) 15	20	15	20	15	20
Normally Open	VK-9213-60X-4-P VK4-9213-601-4-P VK4-9213-801-4-P*	VB-9223-0-4-P	-12	2-1/2"	60	110	40	91	9	60	125	125	91	125	30	125						
			-13	3"	41	75	27	62	5	41	90	125	62	125	19	90						
	VK-9213-60X-5-P VK4-9213-601-5-P VK4-9213-801-5-P* VK4-9213-811-5-P*	VB-9213-0-5-P	-12	2-1/2"	60	110	40	91	9	60	125	125	91	125	30	125						
			-13	3"	41	75	27	62	5	41	90	125	62	125	19	90						
			-14	4"	22	41	14	33	2	22	48	89	33	73	10	48						
			-15	5"													31	56	20	46	5	31
			-16	6"													21	38	14	31	3	21
Normally Closed	VK-9223-60X-4-P VK4-9223-603-4-P VK4-9223-803-4-P*	VB-9223-0-4-P	-12	2-1/2"	9		30		60		30		70		125							
			-13	3"	5		19		41		19		48		90							
	VK-9223-60X-5-P VK4-9223-603-5-P VK4-9223-803-5-P* VK4-9223-813-5-P*	VB-9223-0-5-P	-12	2-1/2"	9		30		60		30		70		125							
			-13	3"	5		19		41		19		48		90							
			-14	4"	2		10		22		5		25		49							
			-15	5"													5		15		31	
			-16	6"													3		10		21	

*Factory valve assemblies only available with positive positioner.

†Close-off pressure ratings apply when valves are installed with pressure under the seat.

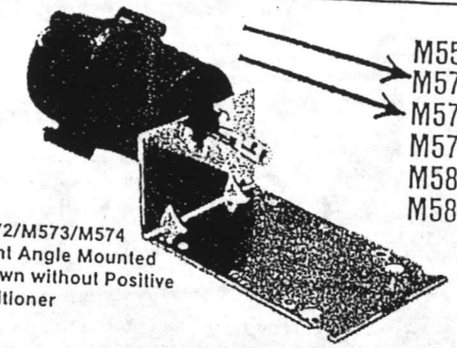
PNEUMATIC

APPLICATION

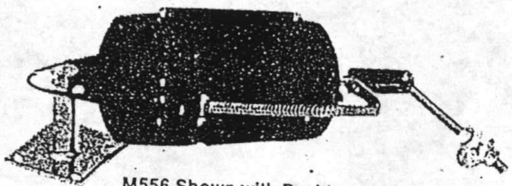
The M556 damper actuator, post mounted, is designed for use in a pneumatic control system to position an air control damper in response to a signal from a pneumatic controller. Other applications include the control of variable fan inlet vanes, centrifugal refrigeration compressor inlet vanes and butterfly valves.

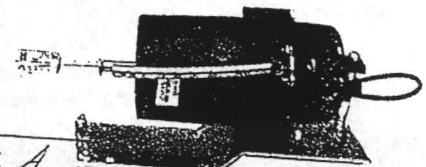
The M570 series damper actuators are used in pneumatic control systems to position automatic air dampers upon receipt of an air pressure signal from a control device. These actuators are equipped with right angle brackets and are adaptable to air conditioning, multi-zone, heating, ventilating, fan coil units, unit ventilators, mixing boxes and VAV terminal boxes.

The M583 is used in classroom type unit ventilators. Special mounting kits are available for adapting the actuator to the various makes and models of classroom type units. The M584 is designed for use on large volume unit ventilators. An internal spring arrangement permits the actuator to operate gradually to a preset percentage of total stroke, hesitate for a preset pressure range, and then complete its full travel. When combined with other control devices, these actuators may be adjusted to perform as required by ASHRAE control cycles for unit ventilators.



M572/M573/M574 Right Angle Mounted Shown without Positive Positioner


M556 Shown with Positive Positioner


M573/M574 Post Mounted Actuator Shown with N800-0555 Positive Positioner

ITEM NO. 3, 4
SUBMITTAL PARA. 1.4.1.A
PRODUCT PARA. 2.1.3.1

SPECIFICATIONS

Construction:
- **Housing**, Glass-filled nylon.
- **Diaphragm**, Neoprene, rolling type.
- **Shaft**, Nickel plated steel except stainless steel on M556.

Stroke: See Table 1.

Spring: Retract actuator shaft on loss of air pressure.

Ambient Temperature Limits: −20 to 180°F (−29 to 82°C).

Supply Air Pressure: Clean, dry, oil free air required.
- **Nominal**, 20 psig (138 kPa). [M580 series nominal 0 to 15 psig (0 to 103 kPa).]
- **Maximum**, 30 psig (207 kPa).

Air Consumption (Positioner Models): 0.017 scfm.

Adjustments:
- **Hesitation Stroke Start Point**, 4 psig (28 kPa); stroke adjustable 20% to 70% prior to 4 psig.
- **Finish Stroke Start Point**, 8 psig (55 kPa); stroke adjustable 80% to 30% after 8 psig.

Connections: Barbed fitting for 1/4" O.D. plastic tubing.

Dimensions:
- **3" Actuator**, 3-3/4" dia. × 5-3/4" long (95 mm × 146 mm).
- **4" Actuator**, 4-5/8" dia. × 7-3/4" long (117 mm × 197 mm).
- **6" Actuator**, 6" dia. × 17" long (152 mm × 432 mm).

ACCESSORIES

AM-111	Slotted crank arm for 5/16" shaft
AM-112	Slotted crank arm for 3/8" shaft
AM-113	Slotted crank arm for 1/2" shaft
AM-115	Slotted crank arm for 7/16" shaft
AM-122	Straight connector
AM-123	Damper clip
AM-125	5/16" × 20 damper rod
AM-125-048	5/16" × 48" damper rod
AM-132	Ball joint connector
N5-75	1/2" I.D. shaft coupling to extend damper drive shafts (includes four set screws)
N800-0555	Positioner (see following page)
N800-1403	Slotted crank arm for 3/8" shaft
N800-1404	Slotted crank arm for 1/2" shaft
N800-1414	3-hole crank arm for 3/8" shaft (for 2", 3", 4" strokes)
N800-1415	3-hole crank arm for 1/2" shaft (for 2", 3", 4" strokes)

Continued on next page

M556, M570 Series, M580 Series Continued from preceding page

TABLE 1. SPECIFICATIONS

2" Stroke (3 sq. in.)	2" Stroke (7 sq. in.)	3" Stroke (7 sq. in.)	3" Stroke (11 sq. in.)	4" Stroke (11 sq. in.)	6" Stroke (24.8 sq. in.)	Spring Range psig	Mounting	Description
	M583-0520*					1 to 4 & 8 to 13	Post-mtd.	Actuator with stamped clevis, clevis pin & bracket; for use on air handlers where factory mounting has not been established
			M584-0211*				Right-angle	Actuator with pushrod and stamped crankarm for 90° rotation of 1/2" damper shafts
M572-2308		M573-2108		M574-2208		3 to 12	Right-angle	Actuator with ball joint to accept 5/16" push rod
M572-2311		M573-2111		M574-2211			Right-angle	Actuator with complete linkage for 1/2" damper shafts
		M573-2520		M574-2520			Post-mtd.	Actuator with clevis and pin
M572-8308		M573-8108		M574-8208		4 to 8	Right-angle	Actuator with ball joint to accept 5/16" push rod
M572-8311		M573-8111		M574-8211			Right-angle	Actuator with complete linkage for 1/2" damper shafts
		M573-8520		M574-8520			Post-mtd.	Actuator with clevis and pin
M572-3308		M573-3108		M574-3208		5 to 10	Right-angle	Actuator with ball joint to accept 5/16" push rod
M572-3311		M573-3111		M574-3211			Right-angle	Actuator with complete linkage for 1/2" damper shafts
		M573-3520		M574-3520			Post-mtd.	Actuator with clevis and pin
		M573-1108		M574-1208		8 to 13	Right-angle	Actuator with complete linkage and positive positioner for 5/16" push rod and 1/2" damper shafts**
		M573-1111		M574-1211			Right-angle	
		M573-1520		M574-1520			Post-mtd.	Actuator with positive positioner**
M572-5308		M573-5108		M574-5208			Right-angle	Actuator with ball joint to accept 5/16" push rod
M572-5311		M573-5111		M574-5211			Right-angle	Actuator with complete linkage for 1/2" damper shafts
		M573-5520		M574-5520			Post-mtd.	Actuator with clevis and pin
					M556-14		Swivel-mtd.	60° to 120° adj. linkage to accept 1/2" shafts w/positioner**
					M556-51**			60° to 120° adjustable linkage to accept 1/2" shafts
		M573-6108		M574-6208		10 to 15	Right-angle	Actuator with ball joint to accept 5/16" push rod
		M573-6111		M574-6211			Right-angle	Actuator with complete linkage for 1/2" damper shafts
				M574-6520			Post-mtd.	Actuator

*Total stroke may be obtained in two stages, 1 to 4 and 8 to 13 psig. No movement from 4 to 8 psig.
**A 10 psi span positive positioner spring is also supplied with the actuator.

TABLE 2. COMPETITIVE CROSS REFERENCE

Robertshaw Model Number	Recent Robertshaw	Barber-Colman	Honeywell	Johnson	Powers
M556	M506	MK-7101 Series MK-7121 Series	MP904A	D-3240 Series	PM331-6X4
M572	M552 M502	MK-2400 Series	MP909A MP913A	D-251-200 Series	
M573	M553 M503	MK-3000 Series MK-4400	MP516A MP909C MP909E	D-251-300 Series	PM331 (3")
M574	M554 M504	MK-3000 Series	MP909C	D-3153 Series	PM331 (3") PM331 (4")
M583	M563 M523	MK-4451	MP516A Hesitation		
M584	M564 M524	MK-3151		D-255-301	PM331 (4") Hesitation

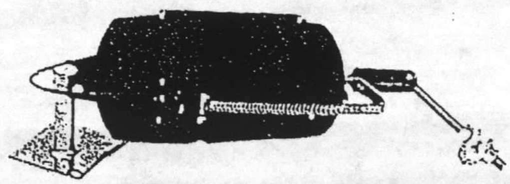
Note: Physical and functional difference exists between models. Review model specifications, applications and dimensions before selection of a replacement.

N800-0555 POSITIVE POSITIONER KIT

The N800-0555 is a positive positioning relay for 3", 4" and 6" pneumatic damper actuators. Has integral branch line adjustable rate of movement needle valve. Feedback arm and spring must be ordered separately (see Table 3).

TABLE 3. SPRING SELECTION FOR N800-0555 POSITIVE POSITIONER

Actuator	For Span of:	Spring Part Number	Feedback Arm
3"	3 psi	N800-2277	N800-1501
	5 psi	N800-2257	
	10 psi	N800-2267	
4"	3 psi	N800-2278	
	5 psi	N800-2258	
	10 psi	N800-2268	
6"	3 psi	N800-2279	
	5 psi	N800-2259	
	10 psi	N800-2269	



Typical Mounting of Positioner on Actuator (actuator not included)

INSTALLATION INSTRUCTIONS

PISTON DAMPER ACTUATOR

2 INCH STROKE

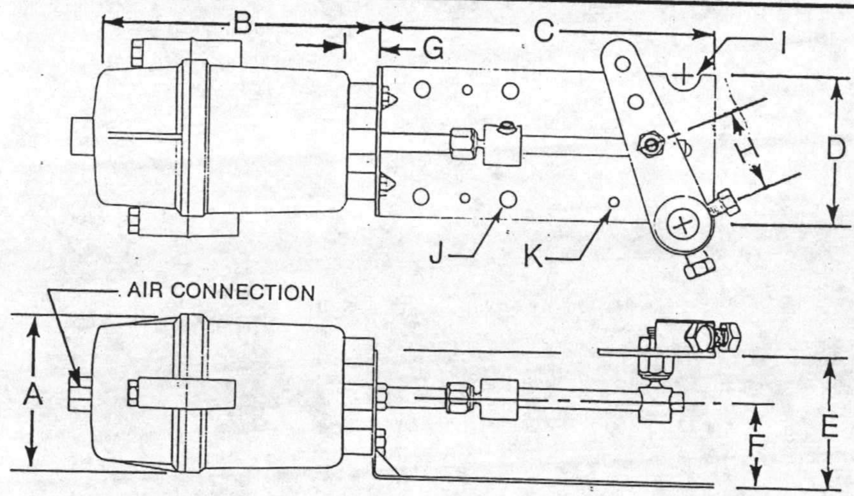
M572

GENERAL DESCRIPTION

The Model M572 piston damper actuator is designed for use in a pneumatic control system to position an air control damper in response to a signal from a pneumatic controller. It has a constant effective piston area to provide linear response to gradual signal changes, although it is also suitable for two-position operation.

The standard M572 is furnished with a right angle mounting bracket for external use on ducts. It is also available with special hardware and a clevis-type end cap for OEM applications. Positive positioning relays are not available for the M572. See Figure 1 for actuator details.

PISTON AREA	3 sq. in. (19cm^2)
NOMINAL STROKE	2 in. (51mm)
NOMINAL RATING (1000 FPM, 305 m/min)	Gradual: 3 sq. ft. (0.3m^2) 2-Position: 4.5 sq. ft. (0.4m^2)
AIR CONNECTION	3/16" (4.8mm) nipple for 1/4" (6.4mm) O.D. tubing



	DIMENSIONS, INCHES (mm)
A	2-5/8 (67)
B	4-3/4 (121)
C	5-9/16 (141)
D	2-7/16 (62)
E	2-1/8 (54)
F	1-3/8 (35)
G	1/2 (13)
H	1.41 (36)
I	2 Shaft Notches 1/2 (13) Dia.
J	5 Mounting Holes 9/32 (7) Dia.
K	4 Mounting Holes 3/16 (5) Dia.

FIGURE 1 — M572 ACTUATOR APPEARANCE AND DIMENSIONS.

INSTALLATION

The standard M572 actuator is furnished with a right angle bracket for mounting on the external surface of a duct or terminal box to operate an air control damper (see Figure 2). The actuator spring range and linkage components for driving dampers with 1/2" (13mm) or 3/8" (10mm) shafts are determined by selection of the proper model number suffix (see Model Number Book).

When ordered properly, the control damper will have a shaft extension for the actuator. The extension will be in its retracted or "stored" position when shipped and must be extended and locked in position with its set screws or through bolts.

Secondly, the "normal" position of the damper blades (open or closed when signal air is removed and the actuator piston retracts) and direction of shaft rotation as the piston is extended must be determined to establish the mounting position of the actuator bracket. The standard right angle bracket has two locator notches ("dimension I" in Figure 1) for the 2 inch (51mm) stroke linkage, the choice of a locator being based on whether clockwise or counterclockwise rotation is required as the piston shaft is extended by increasing signal pressure.

The pre-assembled crank arm is then slipped over the damper shaft extension and, when properly positioned, the bracket is secured to the duct surface by driving sheet metal screws through its mounting holes, using care not to obstruct movement of the damper blades. If the duct is to be insulated, suitable standoff posts and bolts should be substituted for the sheet metal screws. (NOTE: 2 inch stroke actuators use the innermost pivot hole of the crank arm.)

4A

The final installation step of locking the crank arm to the damper shaft extension should be done when control air is available or by means of a squeeze bulb:

a. For a normally closed damper, apply air pressure to the actuator equal to the **low** end of its spring range, e.g.: 4 psig (28 kPa) for a 4 to 8 psig (28 to 55 kPa) spring, then close the damper blades against their stops; a slot in the end of the extension shaft indicates blade position. After assuring that it is parallel to the duct surface, secure the crank arm to the extension shaft by tightening the two box head screws. When air pressure is removed from the actuator, its residual low end spring force will provide additional damper closeoff pressure.

b. For a normally open damper, apply air pressure to the actuator equal to the **high** end of its spring range, e.g.: 8 psig (55 kPa) for a 4 to 8 psig (28 to 55 kPa) spring, then close the damper blades against their stops. Secure the crank arm to the drive shaft as described above. Signal pressure above the spring range will then provide additional closeoff force.

NOTE: The standard actuator hardware will rotate a damper 90° for the full actuator stroke. If less rotation is desired, a stop collar (Model N800-1151) may be applied to the actuator shaft to limit its return stroke.

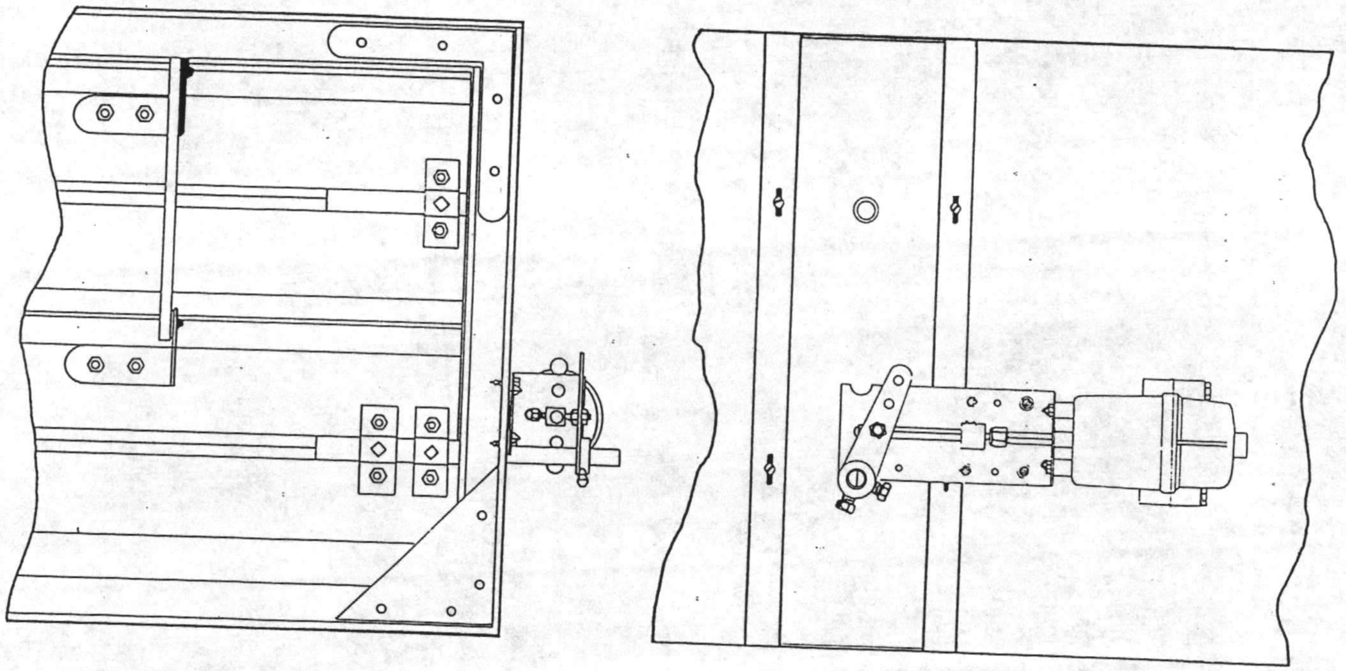


FIGURE 2 — M572 ACTUATOR EXTERNAL MOUNTING.

CALIBRATION & ADJUSTMENT INSTRUCTIONS

PISTON DAMPER ACTUATOR → M572

2 INCH STROKE

CALIBRATION

The Model M572 piston damper actuator is available only with a right angle mounting bracket, but with a selection of fixed spring ranges and linkage hardware. It is not available with a positive positioning relay and requires no factory calibration. See Figure 1 for actuator appearance and linkage details.

PISTON AREA	3 sq. in. (19cm^2)
NOMINAL STROKE	2 in. (51mm)
AIR CONNECTION	3/16" (4.8mm) nipple for 1/4" (6.4mm) O.D. tubing

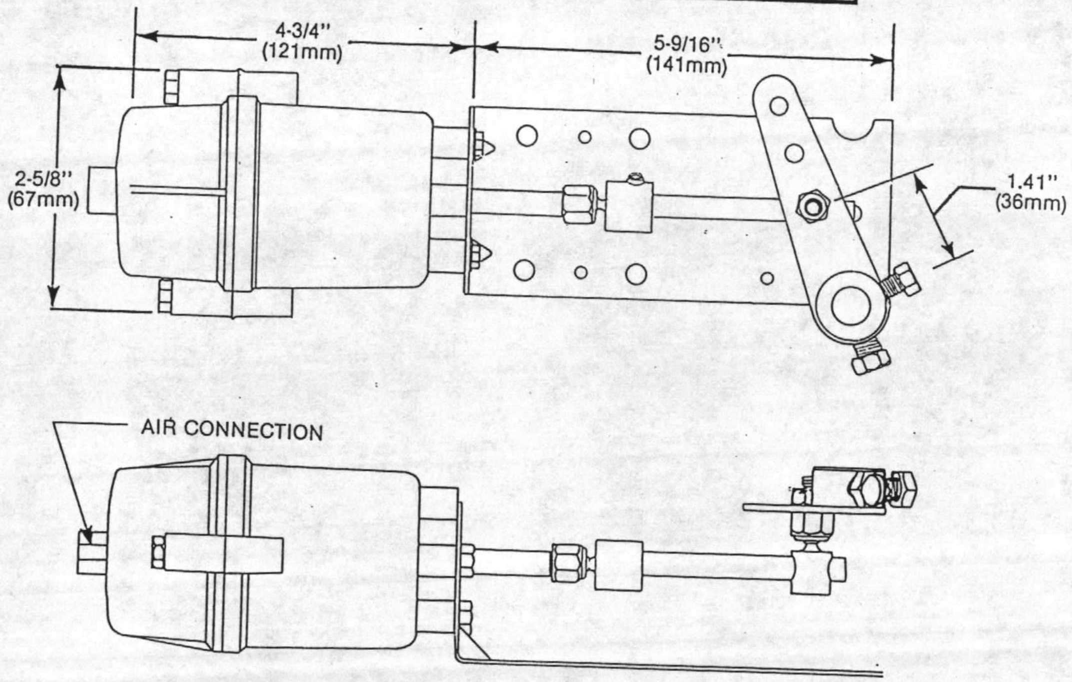


FIGURE 1 — M572 ACTUATOR APPEARANCE.

ADJUSTMENT

Spring Range: The range of the factory installed piston actuator spring is not adjustable.

Stroke: The standard actuator hardware will rotate a damper 90° for the full actuator stroke. If less rotation is desired, a stop collar (Model N800-1151) may be applied to the actuator shaft to limit its return stroke.

ROBERTSHAW CONTROLS COMPANY • CONTROL SYSTEMS DIVISION

4C

INSTALLATION INSTRUCTIONS

PISTON DAMPER ACTUATORS

3- AND 4-INCH STROKES

M573
M574
M594

GENERAL DESCRIPTION

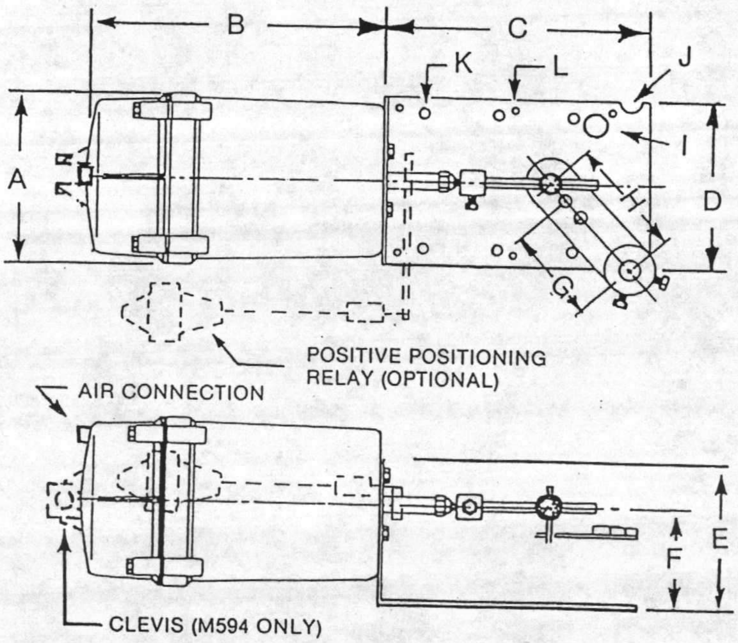
The Models M573, M574 and M594 piston damper actuators are designed for use in pneumatic control systems to position an air control damper in response to a signal from a pneumatic controller. The M573 and M574 housings are glass filled Nylon; the M594 housing is cast zinc.

These actuators have a constant effective piston area to provide linear response to gradual signal changes, although they are also suitable for two-position operation.

All models are available with a right angle bracket for external mounting on a duct or with a post mounting bracket for internal mounting on a damper frame. They are also available with special hardware for OEM use. Positive positioning relays are optional on all models. See Figures 1 and 2 for actuator details.

MODEL	M573	M574 & M594
PISTON AREA	7 sq. in. (45 cm²)	11 sq. in. (71 cm²)
NOMINAL STROKE	3 in. (76mm)	4 in. (102mm)
NOMINAL RATING (1000 FPM, 305 m/min)	Gradual: 12 sq. ft. (1.1 m²) 2-Position: 15 sq. ft. (1.4 m²)	Gradual: 25 sq. ft. (2.3 m²) 2-Position: 30 sq. ft. (2.8 m²)
AIR CONNECTIONS (INCL. POSITIONER)	3/16" (4.8mm) nipple for 1/4" (6.4mm) O.D. tubing	M574: 3/16" (4.8mm) nipple for 1/4" (6.4mm) O.D. tubing M594: 1/8" FPT

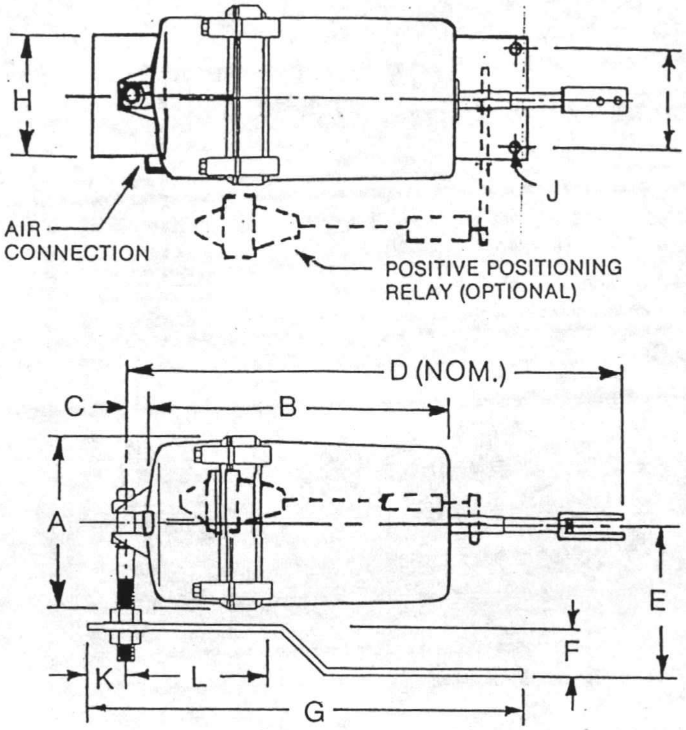
NOTE: When non-positioner actuators are "slaved" from a "master" actuator with a positioner, their control air signal should be taken from a tee fitting inserted into the factory connection between the "master" actuator positioner and the actuator housing (replacing the factory-installed in-line damping restrictor). In addition, all "slave" actuators should be ordered with 8 to 13 psig (55 to 90 kPa) springs to match those furnished with all positioner-model actuators.



	DIMENSIONS, INCHES (mm)	
	M573	M574 & M594
A	3-3/4 (95)	4-5/8 (117)
B	6-3/4 (171)	7-7/8 (200)
C	7-1/4 (184)	
D	4-1/2 (114)	
E	3 (76)	
F	2-5/8 (67)	
G	2.12 (54)	NA
H	NA	2.83 (72)
I	2 Shaft Holes 9/16 (14) Dia.	NA
J	NA	2 Shaft Notches 9/16 (14) Dia.
K	6 Mounting Holes 9/32 (7) Dia.	
L	6 Mounting Holes 3/16 (5) Dia.	

FIGURE 1 — RIGHT ANGLE MOUNTING FOR EXTERNAL APPLICATIONS.

4D



	DIMENSIONS, INCHES (mm)	
	M573	M574 & M594
A	3-3/4 (95)	4-5/8 (117)
B	5-5/8 (143)	7-3/4 (197)
C	9/16 (14)	9/16 (14)
D	10-1/2 (267)	12-1/2 (318)
E	3-1/4 to 4-1/8 (83 to 105)	3-3/8 to 4-1/8 (86 to 105)
F	7/8 (22)	
G	11-5/8 (295)	
H	3 (76)	
I	2-1/2 (64)	
J	8 Mounting Holes 9/32 (7) Dia.	
K	1 (25)	
L	Post Adjustment Slot 3-5/8 (92) Travel	

FIGURE 2 — POST MOUNTING FOR INTERNAL APPLICATIONS.

INSTALLATION

EXTERNAL MOUNTING: Whenever feasible, piston actuators operating air control dampers should be mounted on the external surface of ducts by means of right angle brackets (see Figure 3). By selection of the proper model number and suffix (see Model Number Book), actuators of the proper size (effective area and stroke), spring range and positioner option can be obtained complete with the right angle bracket and the necessary linkage components for driving dampers with 1/2″ (13mm) or 3/8″ (10mm) shafts.

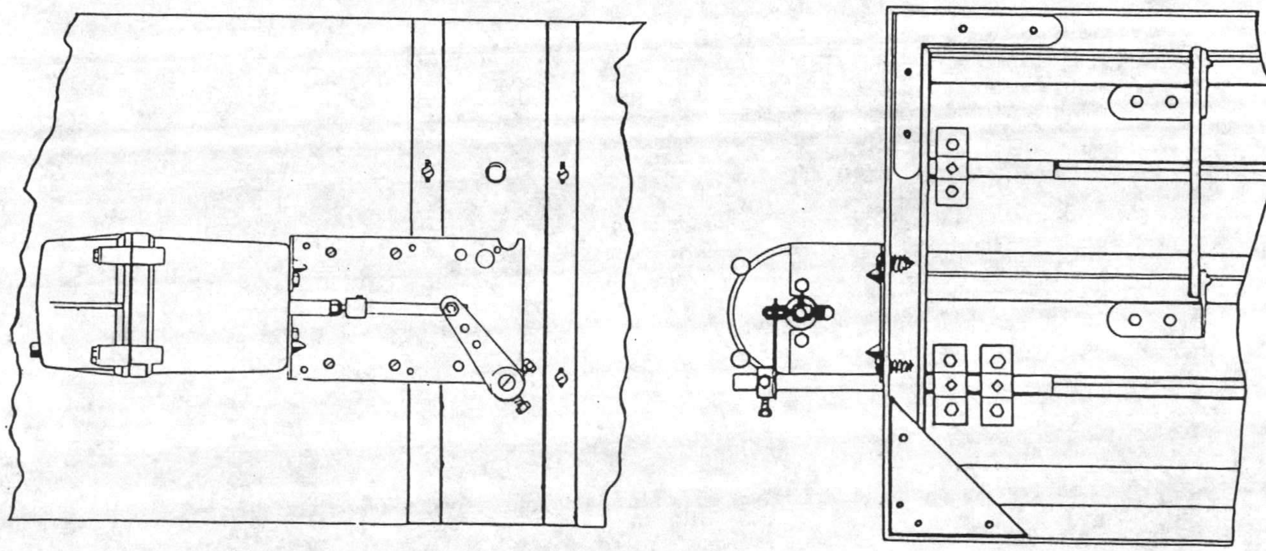


FIGURE 3 — TYPICAL EXTERNAL ACTUATOR MOUNTING (MODEL M574 SHOWN).

When ordered properly, the control damper will have one or more shaft extensions for the required number of actuators. These extensions will be in their retracted or "stored" positions when shipped and must be extended and locked in position with their set screws or through bolts.

Next, the "normal" position of the damper blades (open or closed when signal air is removed and the actuator piston retracts) and direction of shaft rotation as the piston is extended must be determined to establish the mounting position of the actuator bracket. The standard right angle bracket has two locator holes ("dimension I" in Figure 1) for 3 inch (76mm) stroke actuators and two locator notches ("dimension J" in Figure 1) for 4 inch (102mm) stroke actuators; the choice of a locator being based on whether clockwise or counterclockwise rotation is required as the piston shaft is extended by increasing signal pressure.

The pre-assembled crank arm is then slipped over the damper shaft extension and, when properly positioned, the bracket is secured to the duct surface by driving sheet metal screws through its mounting holes, using care not to obstruct movement of the damper blades. If the duct is to be insulated, suitable standoff posts and bolts should be substituted for the sheet metal screws. (NOTE: 3 inch stroke actuators use the middle pivot hole of the crank arm; 4 inch stroke actuators use the outermost pivot hole.)

The final installation step of locking the crank arm to the damper shaft extension should be done when control air is available or by means of a squeeze bulb:

a. For a normally closed damper, apply air pressure to the actuator equal to the *low* end of its spring range, e.g.: 4 psig (28 kPa) for a 4 to 8 psig (28 to 55 kPa) spring, then close the damper blades against their stops; a slot in the end of the extension shaft indicates blade position. After assuring that it is parallel to the duct surface, secure the crank arm to the extension shaft by tightening the two hex head screws. When air pressure is removed from the actuator, its residual low end spring force will provide additional damper closeoff pressure.

b. For a normally open damper, apply air pressure to the actuator equal to the *high* end of its spring range, e.g.: 8 psig (55 kPa) for a 4 to 8 psig (28 to 55 kPa) spring, then close the damper blades against their stops. Secure the crank arm to the drive shaft as described above. Signal pressure above the spring range will then provide additional closeoff force.

NOTE: The standard actuator hardware will rotate a damper 90° for full actuator stroke. If less rotation is desired (for either external *or* internal mounting applications), a stop collar (Model N800-1153) may be applied to the actuator shaft to limit its return stroke. Stroke stop screws (Model N800-188x series) are also available to limit actuator shaft extension.

INTERNAL MOUNTING: When necessary, piston actuators may be internally mounted on damper frames (see Figure 4). For these applications, the dampers must be fabricated with mounting brackets affixed to their frames and clevis lugs affixed to their blades (see Figures 5 and 6). The number and location of these items must be specified in advance to meet the actuator application requirements (size, quantity and normal damper position).

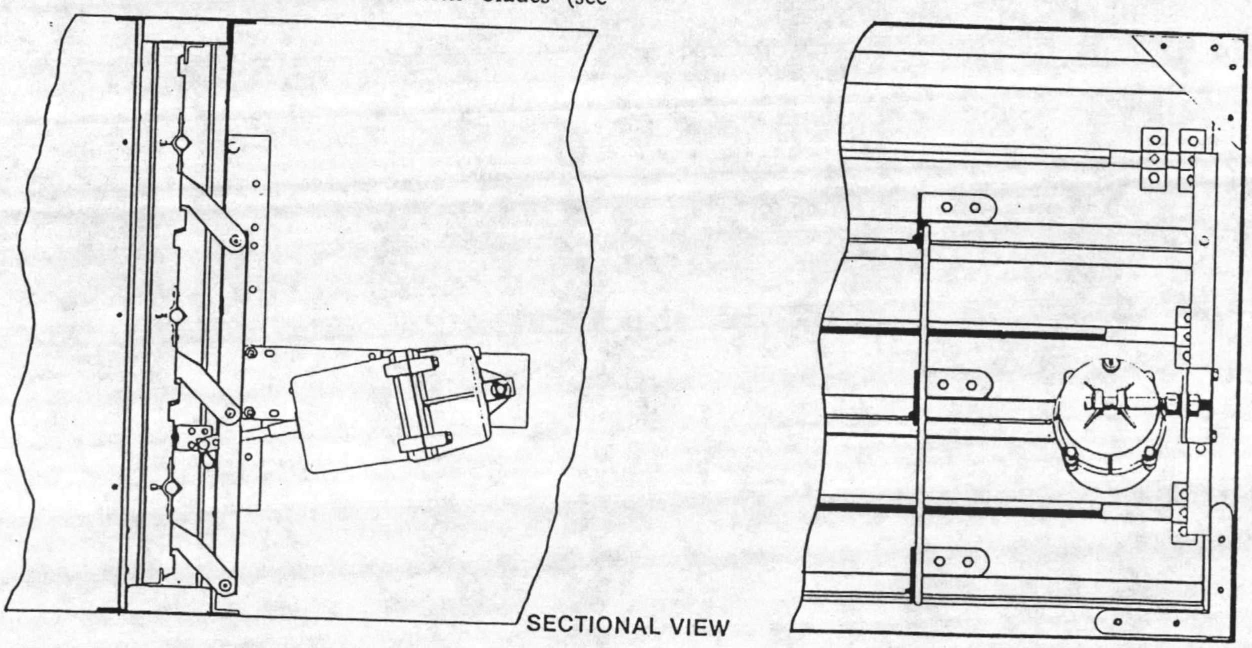


FIGURE 4 — TYPICAL INTERNAL ACTUATOR MOUNTING (M574 SHOWN). 4F

An actuator is field mounted by screwing its offset mounting plate to the proper holes in the mounting bracket and pinning its clevis to the clevis lug.

The actuator post should be loosely connected through the adjustment slot in the mounting plate so that the actuator shaft is in line with the clevis lug.

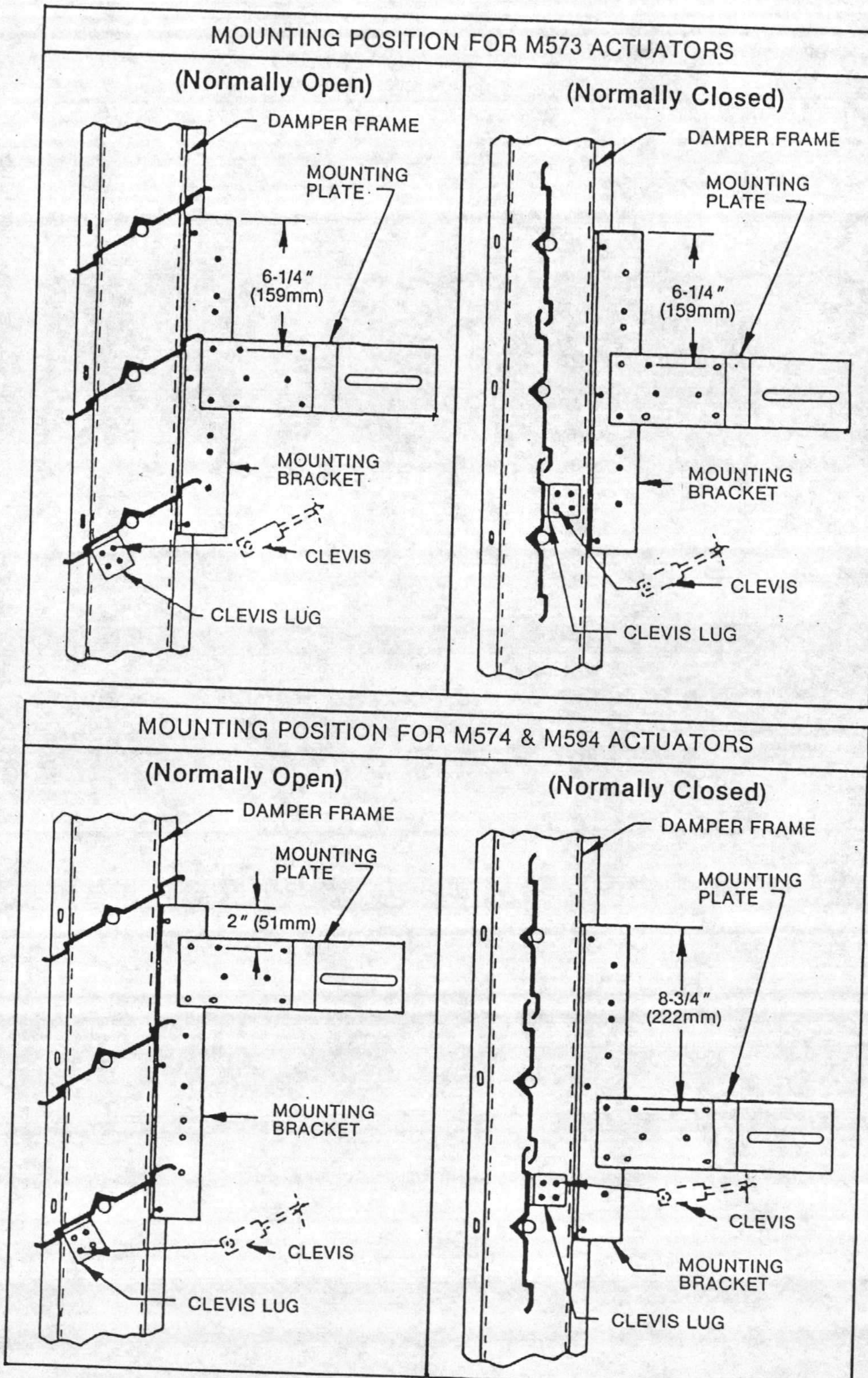


FIGURE 5 — ACTUATOR INTERNAL MOUNTING DETAILS — STYLE "A."

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Using control air or a squeeze bulb, complete the final installation step (similar to externally mounted actuators described above) as follows:

a. For a normally closed damper, apply air pressure to the actuator equal to the *low* end of its spring range, close the damper blades against their stops and then tighten the post mounting nuts to lock the actuator to its mounting plate.

b. For a normally open damper, apply air pressure to the actuator equal to the *high* end of its spring range, close the damper blades against their stops and then tighten the post mounting nuts to lock the actuator to its mounting plate.

NOTE: If an actuator is furnished with a positive positioning relay, the final installation steps described above should be done with the positioner's output line disconnected and signal air applied directly to the actuator housing. (Positioner adjustment is described elsewhere.)

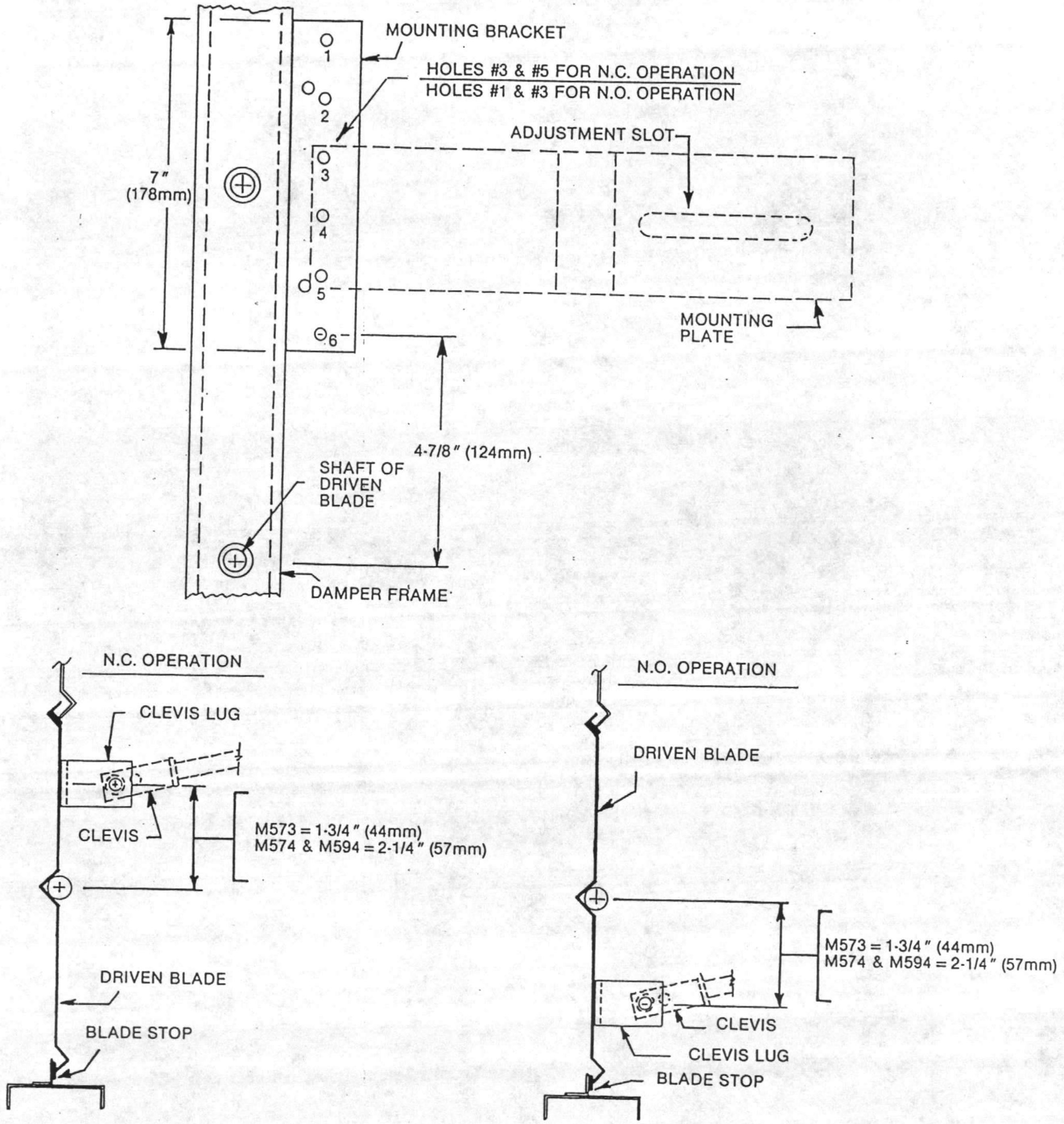

FIGURE 6 — ACTUATOR INTERNAL MOUNTING DETAILS — STYLE "B."

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CALIBRATION & ADJUSTMENT INSTRUCTIONS

PISTON DAMPER ACTUATORS

3-, 4- AND 6-INCH STROKES

M556
M573
M574
M594

CALIBRATION

These piston damper actuator models are available in a variety of sizes (strokes and effective areas), mounting hardware and spring ranges. All models (see Table I) are available with optional positive positioning relays fabricated of ABS plastic or cast zinc. Preferably, positioners should be ordered as factory installed by selecting the proper model number, but they may be field installed by separately ordering the desired positioner model, feedback arm and feedback spring. Positioners on actuators are furnished with 5 psi (34 kPa) span feedback springs installed and are calibrated for 8 to 13 psig (55 to 90 kPa) operation.

TABLE I

ACTUATOR MODEL		M556	M573	M574	M594
ACTUATOR MATERIAL		Glass Filled Nylon			Cast Zinc
STROKE, INCHES (mm)		6 (152)	3 (76)	4 (102)	
EFFECTIVE AREA, SQ. IN. (cm²)		24.8 (160)	7 (45)	11 (71)	
N800-0551 POSITIONER, ABS PLASTIC	ACTUATOR MODEL SUFFIX	-1x	-1xxx	-1xxx	NA
	3 PSI (21 kPa) SPRING	N800-2272	N800-2270	N800-2271	
	5 PSI (34 kPa) SPRING	N800-2252*	N800-2250*	N800-2251*	
	10 PSI (69 kPa) SPRING	N800-2262*	N800-2260	N800-2261	
N800-0552 POSITIONER, CAST ZINC	ACTUATOR MODEL SUFFIX	-9x	-9xxx	-9xxx	-1xxx
	5 PSI (34 kPa) SPRING	N800-2256*	N800-2254*	N800-2253*	
	10 PSI (69 kPa) SPRING	N80-2266	N800-2264	N800-2263	
FEEDBACK ARM		N800-1500*			

* Furnished with positioner-model actuator; other springs must be ordered separately.

ADJUSTMENT

Spring Range: The range of the factory installed piston actuator spring is not adjustable.

Positive Positioner (Optional): Two models of positioners are used on these damper actuators, ABS plastic Model N800-0551 (see Figure 1) and cast zinc Model N800-0552 (see Figure 2). These positioners are similar in function and mounting arrangement; they differ only in the location of the start point adjusting screw and the location and type of air connections. Each requires a signal connection and a main air connection with a maximum pressure of 30 psig (207 kPa). The positioner output is factory-connected to the actuator signal port. (NOTE: On M573, M574 and M594 actuators, this connection is made through an in-line restrictor to damp possible oscillations due to the large air capacity of the positioner relay. It is not required on M556 actuators. The restrictor is included with positioners ordered separately.) Adjustments are as follows:

a. The *span* (or *throttling range*) of the actuator (signal pressure change required to produce full stroke) is determined by feedback spring selection (see Table I) and is not further adjustable.

b. If the factory-calibrated operating range is not satisfactory or if an optional 3 psi (21 kPa) or 10 psi (69 kPa) span feedback spring is substituted, the stroke *start point* of the positioner may be adjusted by setting the signal pressure to the desired value and turning the "start point adjustment" (see Figures 1 and 2) by hand until the actuator shaft begins to move from its "normal" (zero pressure) position. The start point setting is adjustable from 3 to 12 psig (21 to 83 kPa).

NOTE: When non-positioner actuators are "slaved" from a "master" actuator with a positioner, their control air signal should be taken from a tee fitting inserted into the factory connection between the "master" actuator positioner and the actuator housing (replacing the restrictor on 3 inch (76mm) and 4 inch (102mm) stroke models). In addition, all "slave" actuators should be ordered with 8 to 13 psig (55 to 90 kPa) springs to match those furnished with all positioner-model actuators.

4I

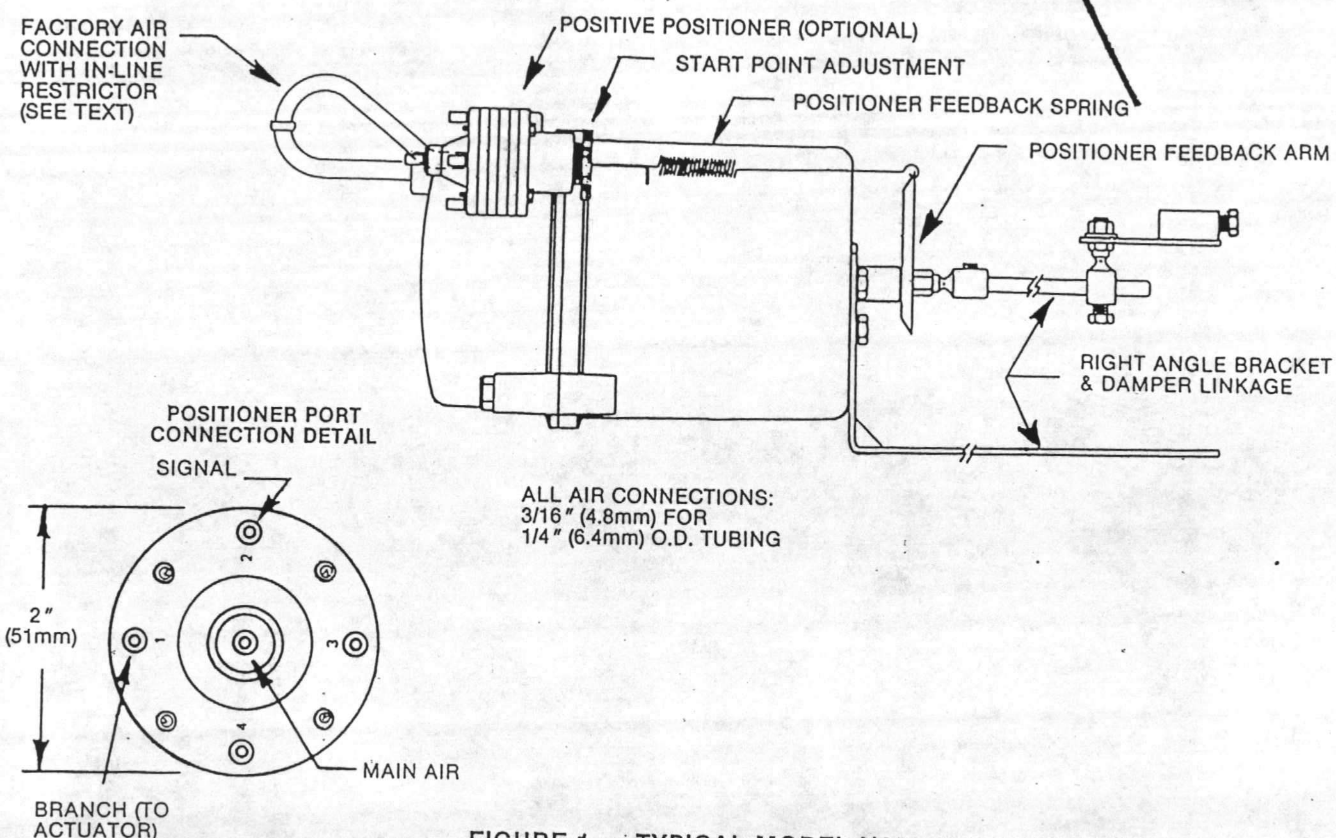


FIGURE 1 — TYPICAL MODEL N800-0551 ABS PLASTIC POSITIONER INSTALLATION (SHOWN ON M574 ACTUATOR).

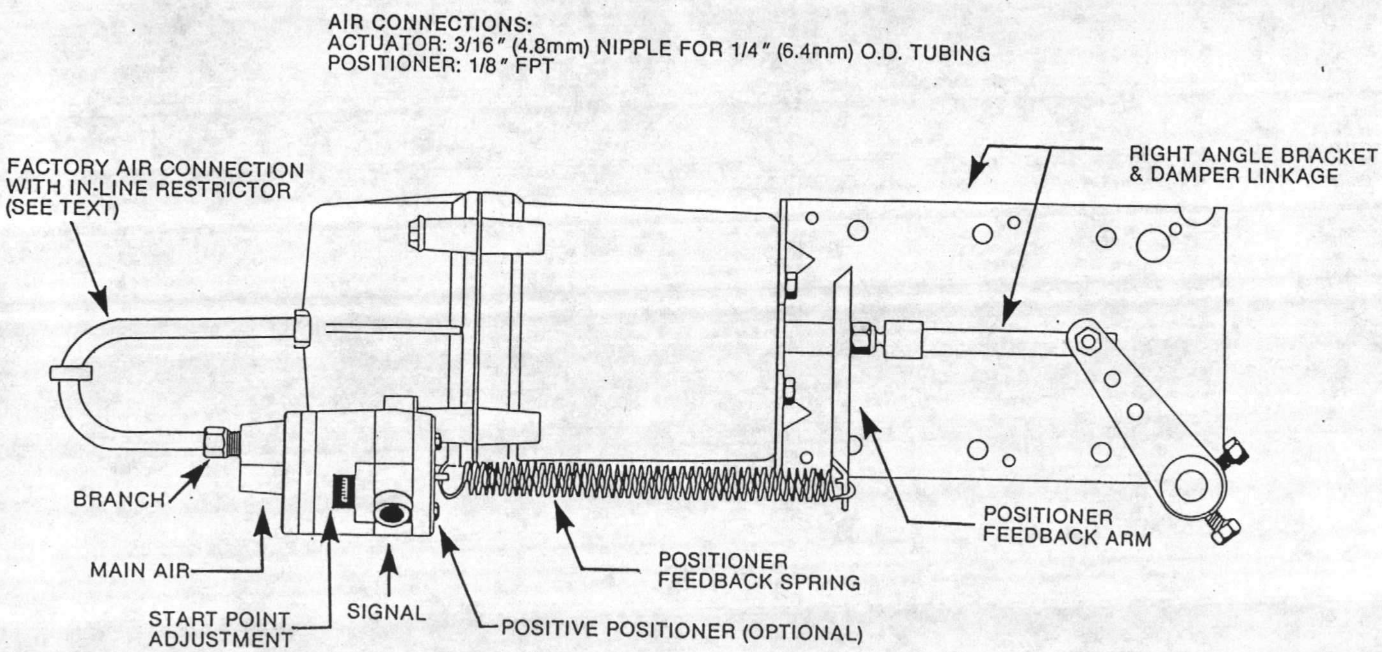


FIGURE 2 — TYPICAL MODEL N800-0552 CAST ZINC POSITIONER INSTALLATION (SHOWN ON M574 ACTUATOR).

ITEM NO. 5
SUBMITTAL PARA. 1.4.1.B
PRODUCT PARA. 2.1.4.1

Pneumodular® Receiver Controller

PNEUMATIC

APPLICATION

The P541 series receiver controllers are used with remote pneumatic transmitters to provide proportional control in pneumatic control systems. They are designed primarily for use with pneumatic transmitters; however, they may be used with any pneumatic device having a calibrated output of 3 to 15 psig such as thermostats or humidistats. Both direct and reverse acting models are available and each device is of the dual-input type, with remote setpoint capability. These devices may be used as single input devices by using only the desired input.

The P541 series receiver controllers may also be used as limit controllers. These devices utilize an integral limit valve which allows them to be indexed internally for limit control applications. The direct acting model may be used as a low limit controller, and the reverse acting model may be used a high limit controller in applications requiring such devices.

The design of the P541 series receiver controllers incorporates the pilot-bleed relay and pneumatic feedback principles usually found in industrial type instruments. These design features assure accuracy, linearity and stability over the entire operating range.

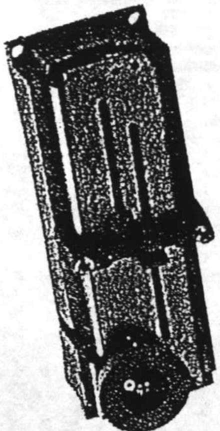
SPECIFICATIONS

Construction: Glass-filled nylon.
Control Action: Direct acting or reverse acting, determined by model selection.
Supply Air Pressure: Clean, dry, oil free air required.
Normal, 4 to 22 psig (28 to 152 kPa).
Maximum, 30 psig (207 kPa).
Air Consumption: 1.25 scfh, maximum.
Air Flow Capacity: 8.0 scfh.
Connections: Barbed nipples for 1/4" O.D. polyethylene or 5/32" I.D. polyurethane tubing.
Authority: Adjustable; 10 to 300% of primary signal input.
Reset Action: Port R (reset signal) provides reverse reset. To obtain direct reset requires P541-RA with 60% authority and 40% throttling range to reverse the transmitter's 3 to 15 psi signal to 15 to 3 psi.
Throttling Range: Adjustable; 2 to 40%/12 psi.
Setpoint: Adjustable; graduated dial with 0.25 psi divisions.
CPA (Remote Setpoint Adjustment): ±10% of primary transmitter span.
Ambient Temperature Limits: 40 to 140°F (4 to 60°C).
Mounting: Designed for use on MCS-S manifold socket. These devices can also be surface mounted by using an optional K504 mounting bracket.
Dimensions:
P541, 1-63/64" high × 5-25/32" wide × 2-1/4" deep (50 mm × 147 mm × 57 mm).
K504, 5-1/2" high × 4-1/2" wide × 2" deep (140 mm × 114 mm × 51 mm).

TABLE 1. SPECIFICATIONS

Model Number	Action	Limit Application
P541	DA	Low Limit
P541-RA	RA	High Limit

P541 Series



ACCESSORIES

K604	Mounting bracket
K541	Cover
MCS Series	Pneumodular accessores
N2-4	5/64" hexhead wrench — calibration tool
N100-0010	Restrictor tee for use with 1/4" polyethylene or 5/32" polyurethane tubing
N100-2501	In-line resistor
S510	Remote setpoint adjustment
N100-2597	Calibration kit

TABLE 2. ACTIVE CONNECTIONS

Port	Connected to
B	Branch output
M	Main air
S	Primary signal input
R	Reset signal input
C	Control Point Adjustment

TABLE 3. SETPOINT DIAL LABELS (order separately)

Model	English	Model	Metric
300-25	0 to 100°F	300-37	-18 to 38°C
300-26	-40 to 160°F	300-36	-40 to 72°C
300-27	40 to 140°F	300-39	4 to 60°C
300-28	40 to 240°F	300-38	4 to 116°C
300-29	50 to 90°F	300-41	10 to 32°C
300-30	40 to 100°F	300-40	5 to 38°C
300-31	-25 to 125°F	300-42	-32 to 52°C
300-32	-5 to 5" W.G.		
300-33	0 to 2" W.G.	300-44	0 to 50 mm W.G.
300-34	0 to 7" W.G.	300-45	0 to 175 mm W.G.
300-35	30 to 80% R.H.		
300-46	-0.5 to 0.5" W.G.	300-43	-13 to 13 mm W.G.
300-47	0 to 3" W.G.	300-50	0 to 76 mm W.G.
300-48	0 to 10" W.G.	300-51	0 to 254 mm W.G.
300-52	-30 to 80°F	300-53	-1 to 27°C
300-54	-0.05 to 0.2" W.G.	300-55	-1.3 to 5.2 mm W.G.
300-56	-10 to 40 psig	300-59	-0.7 to 2.76 Bar
300-57	0 to 150 psig	300-60	0 to 10.34 Bar
300-58	0 to 300 psig	300-61	0 to 20.69 Bar
300-70	0 to 50 psig	300-84	0 to 3.45 Bar
300-71	0 to 100 psig	300-85	0 to 6.9 Bar
300-72	0 to 100% R.H.		
300-80	0 to 2000 FPM		
300-81	0 to 3000 FPM		
300-82	0 to 4000 FPM		
300-83	0 to 5500 FPM		
300-86	50 to 100°F		
300-87	50 to 150°F		

Continued on next page

P541 Series Continued from preceding page

TABLE 4. COMPETITIVE CROSS REFERENCE

Robertshaw Model No.	Recent Robertshaw	Barber-Colman	Honeywell	Johnson	Powers
P541	P340	RKS-1001 RKS-2001 RKS-3002 RKS-4002 RKS-5001	RP908A RP908B	T-5302 T-5303 T-9001 T-9002	RC195
P541-RA					

Note: Physical and functional difference exists between models. Review model specifications, applications and dimensions before selection of a replacement.

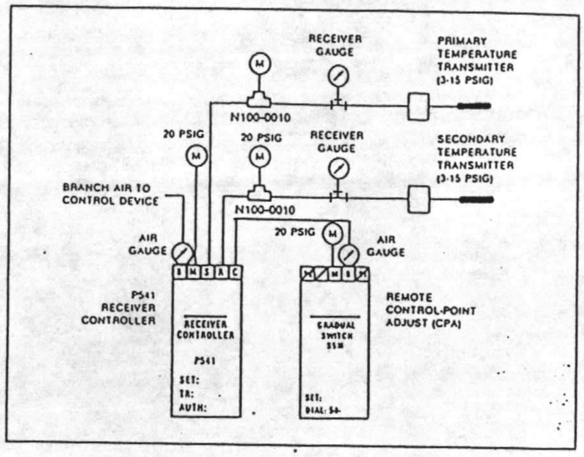


Figure 1. Typical Application

INSTALLATION INSTRUCTIONS

PNEUMODULAR® RECEIVER CONTROLLERS P541 → P541(R.A.)

SOCKET MOUNTING

The assembly of Pneumodular components on a panel mounted manifold backplate is illustrated. A **Manifold Backplate** (MCS-BP) is shown. The MCS-BP is mounted to a panel (cabinet) backplate with 1/4" **Mounting Screws** (MCS-MS).

A **Socket and Plug Assembly** (MCS-S) is mounted on the BP by engaging three socket projections with three backplate openings and pulling downward until a pin on the socket engages a hole in the spring release tab of the backplate with an audible "click." The socket may be removed by depressing the backplate spring release and lifting the socket upward, then outward.

A P541 (or P541-R.A.) receiver controller is mounted on the socket by first placing a **Socket-to-Device Gasket** (MCS-G) in a matching socket depression and then attaching the P541 to the socket with four #6 x 1/2" **Plastite Screws** (MCS-SCREW). The screws are double-helix threaded for quick installation and removal.

A 300-XX series adhesive scale with engineering units may be applied to the P541 set point dial.

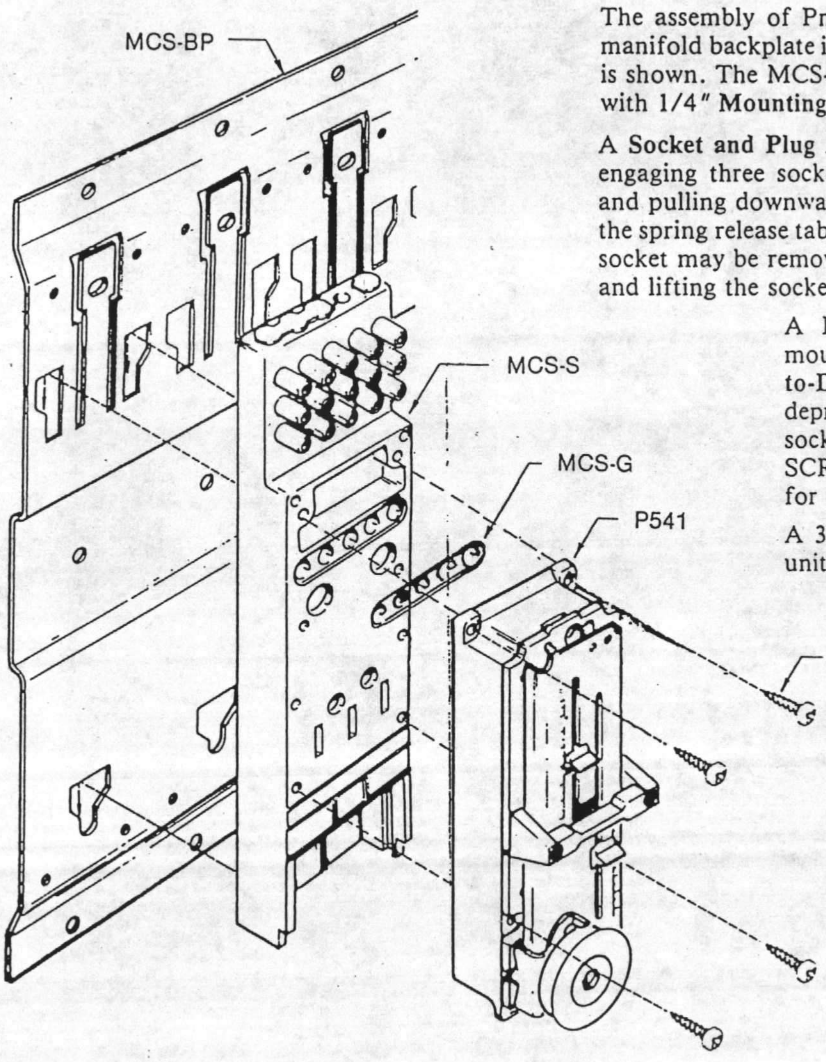


FIGURE 1 — P541 SOCKET MOUNTING DETAIL

6A

BRACKET MOUNTING

P541 series receiver controllers may be mounted exclusive of the socket and backplate by using the K504 mounting kit. The MCS-G gasket is not required for this type of installation; tubes are connected directly to the barbed nipples of the receiver controller which protrude through an opening in the K504 bracket.

Optional stainless steel cover K541 may be snapped onto the receiver controller to provide mechanical protection.

The K504 mounting bracket also has provisions for mounting up to three air gauges (model A201 or equivalent) or receiver gauges (model A253 or equivalent, maximum of two), utilizing MCS-GMF gauge mounting fittings.

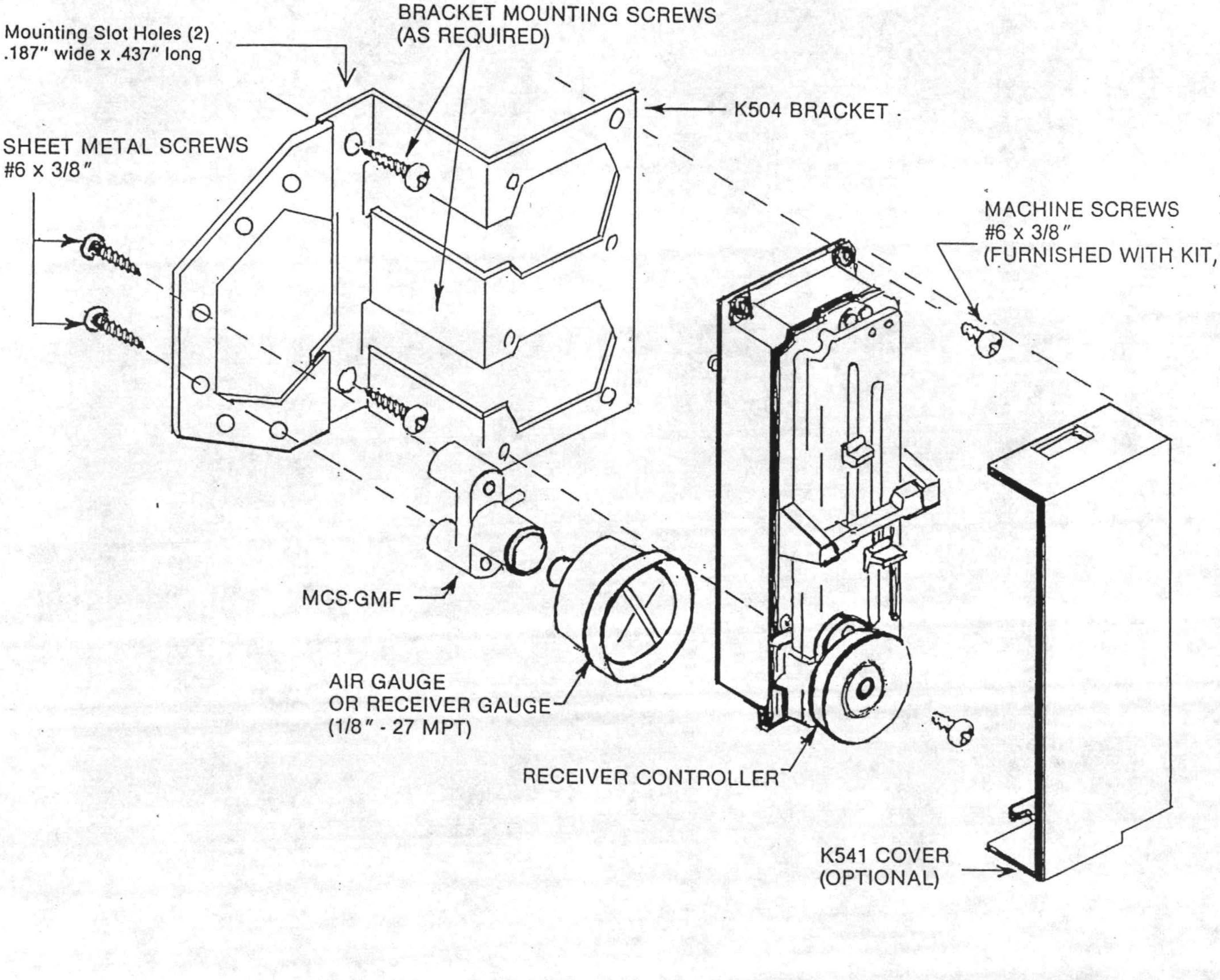


FIGURE 2 — PNEUMODULAR RECEIVER CONTROLLER BRACKET MOUNTING DETAIL (K504)

6B

CALIBRATION & ADJUSTMENT INSTRUCTIONS

PNEUMODULAR® RECEIVER CONTROLLERS

DIRECT AND REVERSE ACTING

P541 P541-RA

CALIBRATION

The Model P541 series receiver controllers utilize input signals from remote sensing devices and adjusting devices to provide proportional control in pneumatic control systems. They are designed primarily for use with Robertshaw pneumatic transmitters; however, they may be used with any pneumatic device having a calibrated output of 3 to 15 psig (21 to 103 kPa), such as thermostats, humidistats or gradual switches. The P541 devices also may be applied as limit controllers. See Table I for model number descriptions and limit functions.

TABLE I

MODEL	TYPE	LIMIT APPLICATION
P541	Direct Acting	Low Limit
P541-RA	Reverse Acting	High Limit

The P541 series controllers are pilot-operated and require a main air connection to port "M" (non-limit application) or port "C" (limit application) of 20 psig (138 kPa). These devices are not factory-calibrated.

ADJUSTMENT

See Table II for adjustment types, ranges and descriptions. Determination of initial settings is an application engineering function and the values should be listed on control drawings or panel labels. Since changes of the throttling range or authority settings or the CPA signal pressure will affect the set point, these values are set first. See Figure 1 for device appearance and location of adjustments.

TABLE II

ADJUSTMENT	RANGE	DESCRIPTION
Set Point	3 to 15 psig[a] (21 to 103 kPa)	The value of the port "S" primary signal that is used to produce the midpoint branch pressure at port "B," usually 9 psig (62 kPa).
Throttling Range (Proportional Band)	2 to 40%, equivalent to 0.24 to 4.8 psi (1.7 to 33.1 kPa)	The selected portion of the port "S" primary signal range that is used to vary the branch pressure at port "B" by 12 psi (83 kPa), normally from 3 to 15 psig (21 to 103 kPa).
Authority	10 to 300%	The effect on the branch pressure at port "B" of a signal change at reset port "R" as a percentage of the effect of the same signal change at primary signal port "S."
Control Point ("CPA")	20%[b] (direct acting)[c]	The amount of set point readjustment caused by a 12 psi (83 kPa) signal change at port "C," usually from 3 to 15 psig (21 to 103 kPa), as a percentage of the primary (port "S") transmitter span.

a - Adhesive dials (300-XX series) are available to convert pressure values to engineering units for all Robertshaw pneumatic transmitters.
b - Usually centered on the set point value to permit CPA (set point) changes of plus and minus 10%.
c - Increased pressure at port "C" raises set point.

6C

Throttling Range: The throttling range (proportional band) is set by positioning the T.R. slide to the desired value.

Authority: The authority is set by positioning the authority slide to the desired value. If the application does not require reset action (no signal to port "R"), a minimum authority setting (10%) is recommended.

Control Point Adjustment: The "CPA" feature of P541 series controllers is a fixed mechanical relationship, so that set point changes are directly proportional to CPA signal changes at port "C". No controller adjustment is required.

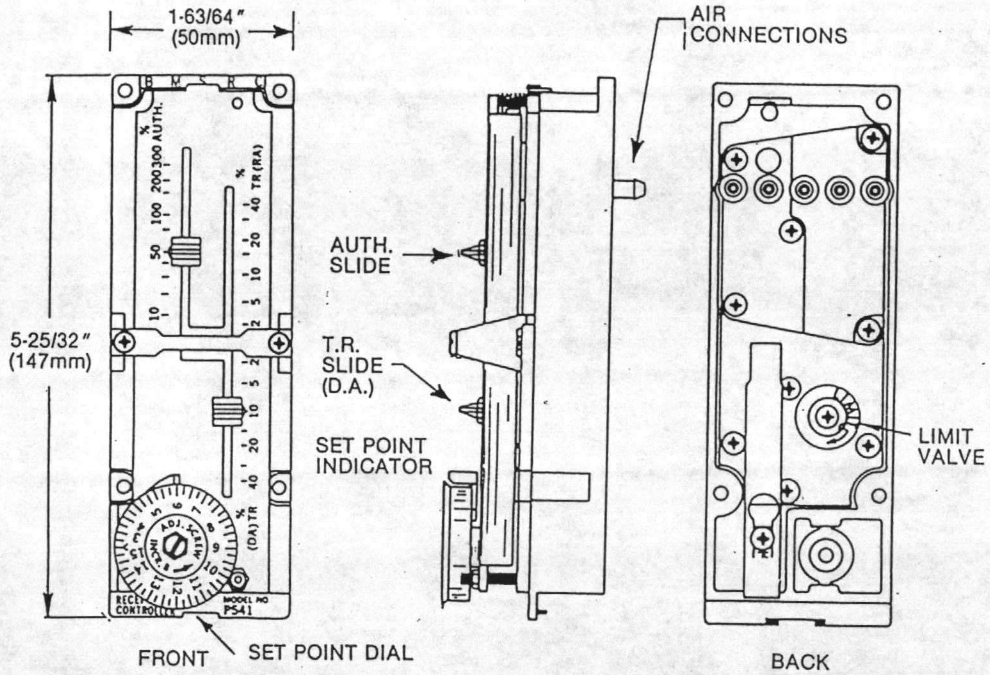


FIGURE 1 — TYPICAL RECEIVER CONTROLLER APPEARANCE (P541 SHOWN).

Set Point (standard): After the throttling range and authority have been set, main air applied to port "M" and the proper "calibration" pressures applied to ports "C" and "R" (if either of these ports is not used for an application, it should be left open to the atmosphere), the pressure representing the desired set point should be applied to port "S." Using the reverse end of thermostat wrench N2-4 (1/4", 6.4mm), rotate the set point dial (see "Increase" arrow on dial) until the branch pressure at port "B" is 9 psig (62 kPa) unless a different "calibration pressure" is designated. The adjustment procedure is completed by lifting the spring-loaded set point dial, rotating it until the port "S" pressure value (or signal value in engineering units, if a series 300-XX set point dial has been applied to the controller) is opposite the set point indicator and then seating the dial on its gear teeth.

After the above adjustment is done, subsequent set point changes can be made by using the 1/4" hex wrench to rotate the set point dial to a new value.

Set Point (alternative): A P541 series controller can be adjusted to any random port "S" signal between 3 and 15 psig (21 and 103 kPa) by adding a final step to the previous procedure: After the set point dial has been indexed to match the *random* pressure at port "S," the 1/4" hex wrench is used to rotate the set point dial until the *desired* setting is opposite the indicator.

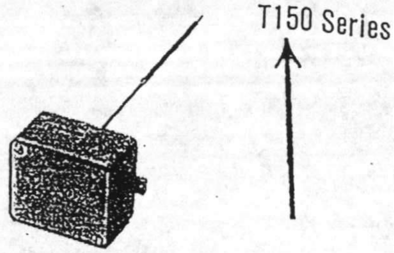
NOTE: In "limit" applications, main air at 20 psig (138 kPa) is applied to *port "C,"* the pneumatic transmitter sensing the limiting variable is connected to port "S," the control signal to be limited is connected to *port "M"* and the resultant limited signal is taken from branch port "B." In addition, the "limit valve" (see Figure 1) on the back of the P541 (Phillips screwhead) must be rotated 60° clockwise to its detent limit position *before* the controller is mounted on a socket. Port "R" remains available for "reset" action, but port "C" is *not* available for "CPA" action. By temporarily maintaining port "M" (signal to be limited) at 20 psig (138 kPa), all adjustments can be made as described above.

6D

APPLICATION

The T150 series pneumatic temperature transmitters are designed to measure air or fluid temperatures in pneumatic control systems and transmit a fixed span, 3 to 15 psig signal to controlling and indicating devices such as receiver controllers, receiver gauges and sensitive pressure switches. These transmitters are available with several types of sensing elements.

The transmitters are "one-pipe" devices requiring an external restricted source of constant pressure control air. Their design features pneumatic feedback to assure accuracy and stability over a wide temperature span.



ITEM NO. 6
SUBMITTAL PARA. 1.4.1.C
PRODUCT PARA. 2.1.5.1

SPECIFICATIONS

Action: Direct, proportional.
Adjustments: None, factory calibrated.
Supply Air Pressure: Clean, dry, oil free air required.
  Nominal, 20 psig ±0.5 psi (138 kPa ±3.4 kPa) through 0.5 scfh restrictor.
  Maximum, 30 psig (207 kPa).
Output Pressure: 3 to 15 psig (21 to 103 kPa).
Air Connection: 1/8"-27 FNPT.
Maximum Case Ambient Temperature: 140°F (60°C).
Construction: Copper element, cast aluminum base, cadmium plated steel cover.
Mounting: Duct or immersion (see Table 1).
Weight: 0.9 lb. (0.4 kg).
Case Dimensions: 2-5/8" high × 3-1/16" wide × 1-3/4" deep (67 mm × 78 mm × 44 mm).

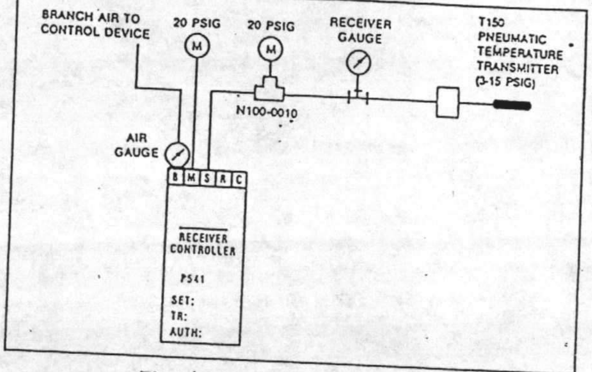


Figure 1. Typical Application

TABLE 1. SPECIFICATIONS

Range (non-adj.) °F (°C)	Span	Mounting	Sensing Element Description	Part No.
40 to 140	100	Duct or immersion	Rigid element, 1/4" × 9-3/8" long (6 mm × 238 mm)	T150-1011
		Duct	Averaging element, 20' long (6 m)	T150-1012
		Duct	Rigid (coiled) element, 10' long (3 m)	T150-1013
0 to 100	100	Duct or immersion	Rigid element, 1/4" × 9-3/8" long (6 mm × 238 mm)	T150-1021
		Duct	Averaging element, 20' long (6 m)	T150-1022
		Duct	Rigid (coiled) element, 10' long (3 m)	T150-1023
40 to 240	200	Duct or immersion	Rigid element, 1/4" × 7-1/16" long (6 mm × 179 mm)	T150-1031
		Duct	10-1/2" × 1/4" (267 mm × 6 mm) bulb with 9" (2.7 m) capillary	T150-1035
-40 to 160	100	Duct or immersion	Rigid element, 1/4" × 7-1/16" long (6 mm × 179 mm)	T150-1041
-25 to 125	150	Duct	4" × 1/4" (102 mm × 6 mm) bulb with 3' (0.9 m) capillary	T150-1054
		Duct	10-1/2" × 1/4" (267 mm × 6 mm) bulb with 9" (2.7 m) capillary	T150-1055
30 to 80	50	Duct	Averaging element, 20' long (6 m)	T150-1062
50 to 100	50	Duct	Rigid (coiled) element, 10" long (25.4 cm)	T150-1073

TABLE 2. COMPETITIVE CROSS REFERENCE

Robertshaw Model No.	Barber-Colman	Honeywell	Johnson	Powers
T150	TKS-2000 TKS-4000 TKS-8000 TKS-9000	LP914A LP915A	T-5210	TT184

Note: Physical and functional difference exists between models. Review model specifications, applications and dimensions before selection of a replacement.

ACCESSORIES (See following page)

100-17	Copper separable socket, 7-1/32" × 1/2" NPT (179 mm × 13 mm)
N4-32	Restrictor, 1.0 scfh, 1/4" O.D. compression fitting
N100-0010	Restrictor tee (red), 1.0 scfh
N100-2501	In-line restrictor, 1.0 scfh

MAINTENANCE PARTS None

Continued on next page

INSTALLATION INSTRUCTIONS

PNEUMATIC TEMPERATURE TRANSMITTER T150

GENERAL DESCRIPTION & DIMENSIONS

T150 transmitters are "one-pipe" devices requiring an externally restricted source of constant pressure control air. These transmitters are available with several types of sensing elements (rigid stem, averaging, remote bulb or a rigid coil for fast response).

RIGID STEM LENGTHS

TEMPERATURE RANGE	DIM. "A"
0 to 100 (-18° to 38°C), 40 to 140°F (4° to 60°C)	9-3/8" (238mm)
-40 to 160 (-40° to 71°C), 40 to 240°F (4° to 116°C)	7-1/16" (179mm)

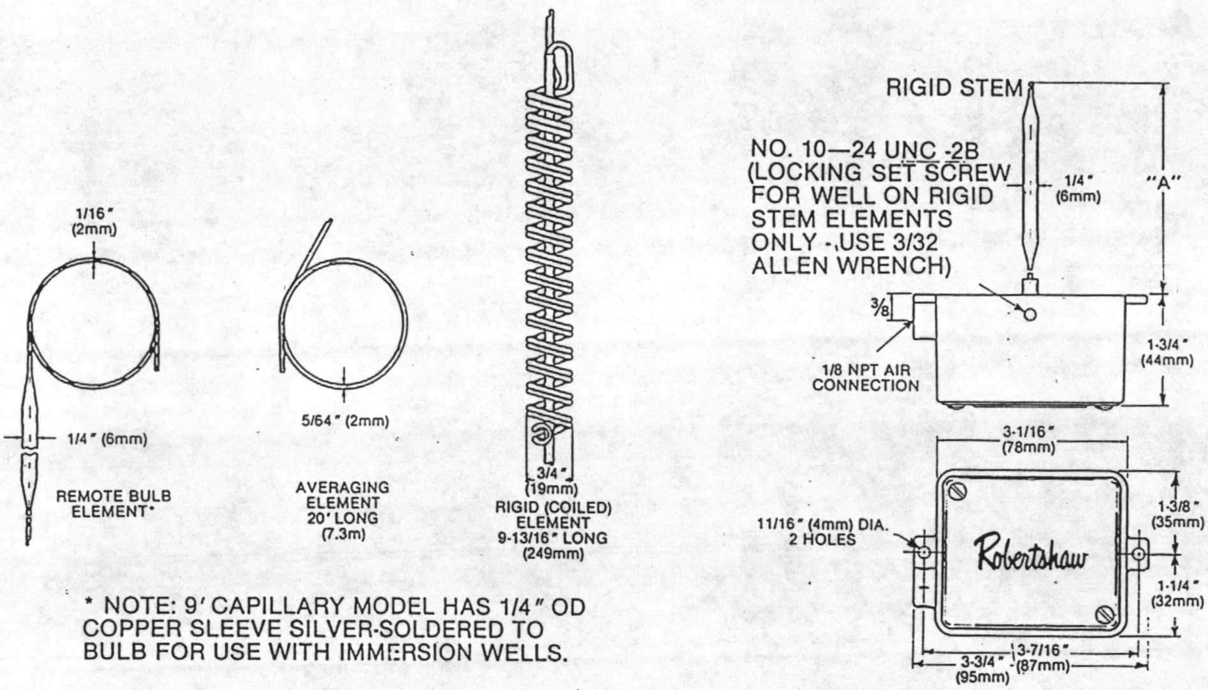


FIGURE 1 — T150 DIMENSIONS

DUCT INSTALLATION

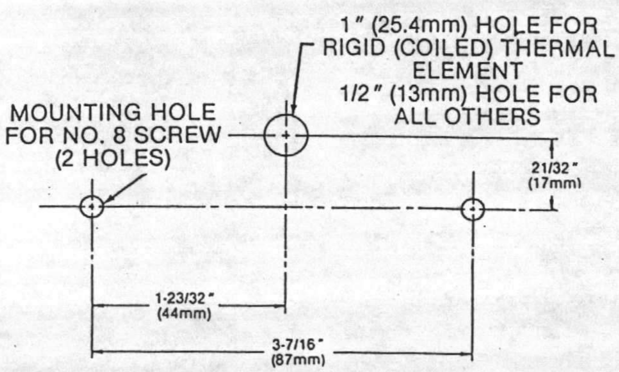


FIGURE 2 — SURFACE MOUNTING HOLE DIMENSIONS

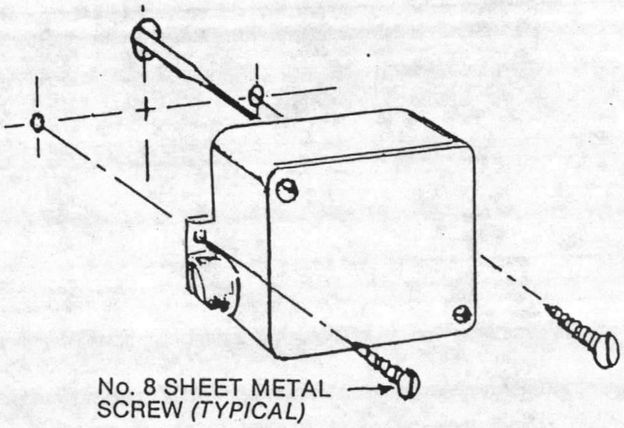


FIGURE 3 — DUCT INSTALLATION DETAIL

DUCT INSTALLATION (Continued)

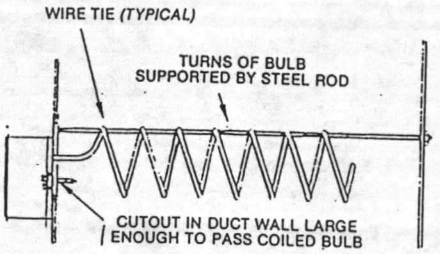


FIGURE 4 — AVERAGING ELEMENT

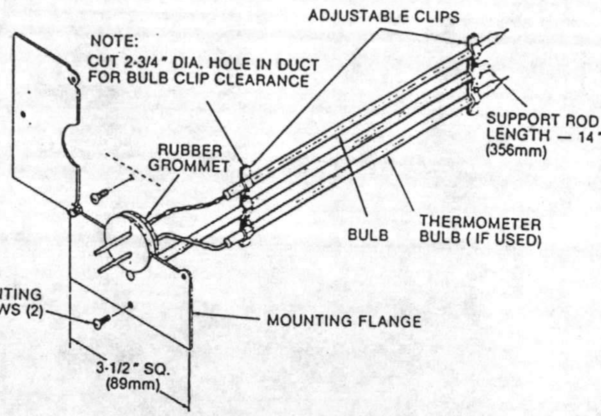
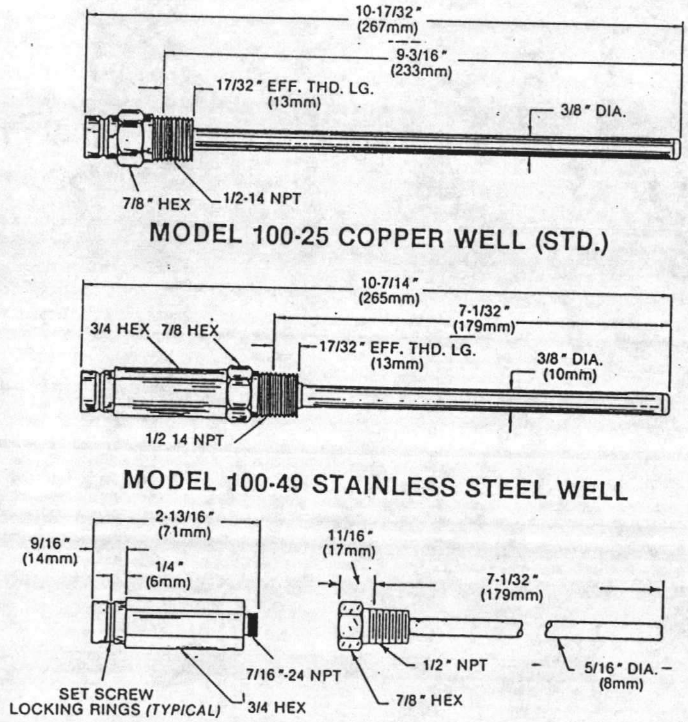


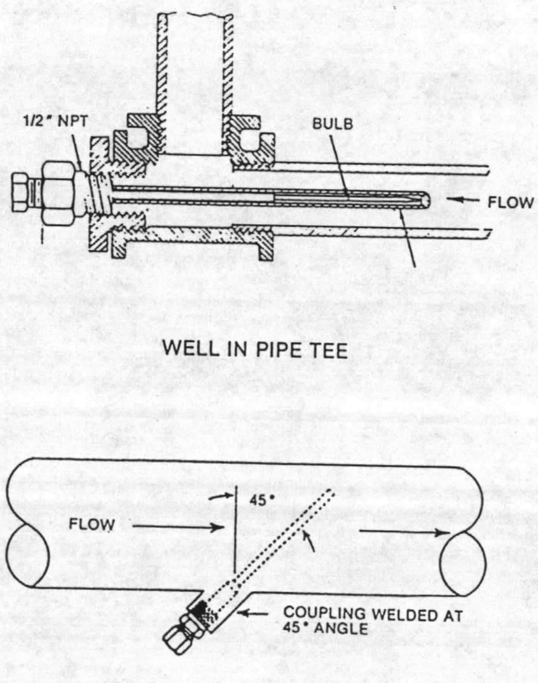
FIGURE 5 — MODEL 100-02 BULB HOLDER FOR REMOTE BULB ELEMENT

IMMERSION INSTALLATION



MODEL 100-47 ADAPTER WITH MODEL 100-17 COPPER WELL (DISCARD UNION NUT AND FERRULE)

FIGURE 6 — T150 IMMERSION WELLS



WELL IN TOP OR SIDE OF PIPE

FIGURE 7 — PIPE INSTALLATION

7B

OUTSIDE WALL INSTALLATION

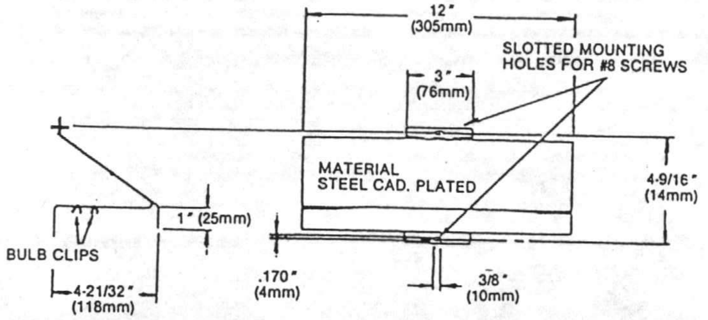


FIGURE 8 — MODEL 100-13 SUNSHIELD FOR MOUNTING TEMPERATURE SENSING BULBS ON OUTSIDE WALLS

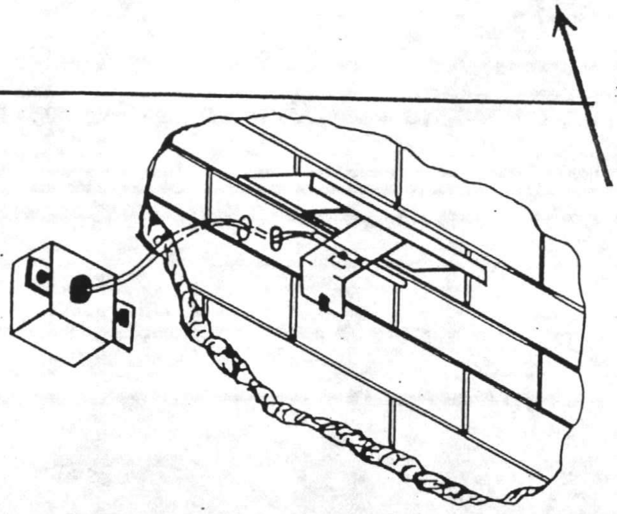


FIGURE 9 — SHIELD ON OUTSIDE WALL

7C

PNEUMATIC TEMPERATURE TRANSMITTER T150

CALIBRATION

The Model T150 Temperature Transmitter measures a system temperature and transmits a proportional pneumatic signal to a calibrated receiver gauge and/or receiver controller. (See table I for complete model number descriptions.) It is a "one-pipe," force-balance transmitter which utilizes an external restrictor in its supply line. It is not intended to be field calibrated. If the output pressure does not correspond to Table II, check the following:

1. The air supply to the restrictor must be 20 psig ± 0.5 psi (138 kPa ± 3.4 kPa) and must be clean, dry and oil-free.
2. The restrictor and the device filter must be free of obstructions.

If, after completing the above checks, the transmitter output varies from Table II, see "Adjustments."

T150 MODEL NUMBERS						
TEMPERATURE RANGE	ELEMENT					
	RIGID 1/4" x 9-3/8"	RIGID 1/4" x 7-1/16"	AVERAGING 20 FT.	COILED 10"	1/4" x 10-1/2" 9 FT. CAPILLARY	1/4" x 4" 3 FT. CAPILLARY
-40°/160°	—	T150-1041	—	—	—	—
-25°/125°	—	—	—	—	—	—
0°/100°	T150-1021	—	T150-1022	T150-1023	T150-1055	T150-1054
30°/80°	—	—	T150-1062	—	—	—
40°/140°	T150-1011	—	T150-1012	T150-1013	—	—
40°/240°	—	T150-1031	—	—	T150-1035	—

TABLE I — T150 MODEL NUMBERS

ADJUSTMENT

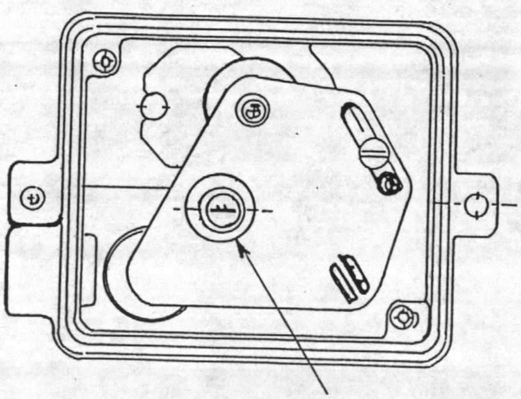


FIGURE 1 — T150 WITH COVER REMOVED

Minor transmitter range adjustments may be accomplished as follows (see Figure 1):

1. With the cover removed, measure the sensed temperature and output pressure with suitable instruments.
2. Turn adjusting screw "A" to shift the output range (clockwise to increase).
3. If output correction is not obtained, no other adjustment should be attempted and device replacement is necessary.

OUTPUT PRESSURES
FOR
PNEUMATIC TEMPERATURE TRANSMITTERS

ACTUAL TEMPERATURE

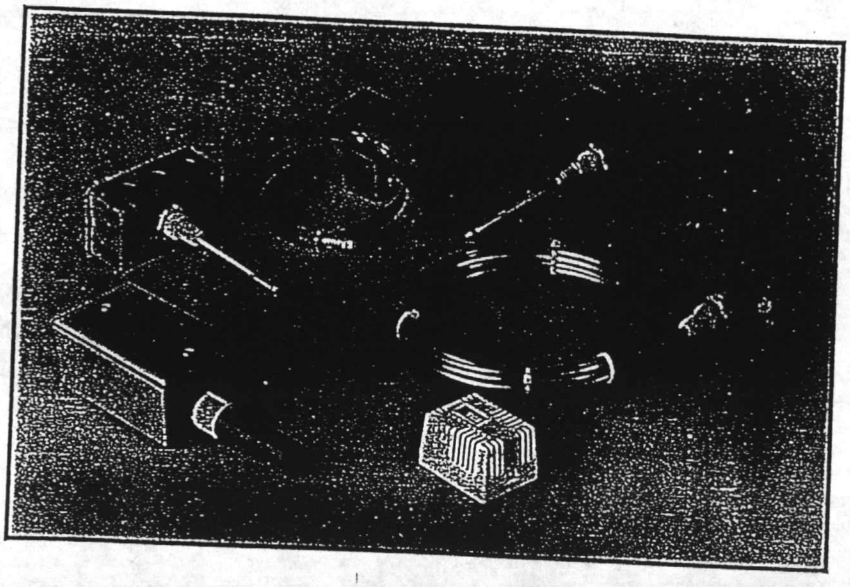
TEMPERATURE RANGE (F)						OUTPUT (psig)
-25 to +125	0 to 100 F	40 to 140 F	-40 to +180 F	40 to 240 F	30 to 80 F	
-25	0	40	-40	40	30	3.0
-22	2	42	-36	44	31	3.24
-19	4	44	-32	48	32	3.48
-16	6	46	-28	52	33	3.72
-13	8	48	-24	56	34	3.96
-10	10	50	-20	60	35	4.2
- 7	12	52	-16	64	36	4.44
- 4	14	54	-12	68	37	4.68
- 1	16	56	- 8	72	38	4.92
2	18	58	- 4	76	39	5.16
5	20	60	0	80	40	5.4
8	22	62	4	84	41	5.64
11	24	64	8	88	42	5.88
14	26	66	12	92	43	6.12
17	28	68	16	96	44	6.36
20	30	70	20	100	45	6.6
23	32	72	24	104	46	6.84
26	34	74	28	108	47	7.08
29	36	76	32	112	48	7.32
32	38	78	36	116	49	7.56
35	40	80	40	120	50	7.8
38	42	82	44	124	51	8.04
41	44	84	48	128	52	8.28
44	46	86	52	132	53	8.52
47	48	88	56	136	54	8.76
50	50	90	60	140	55	9.0
53	52	92	64	144	56	9.24
56	54	94	68	148	57	9.48
59	56	96	72	152	58	9.72
62	58	98	76	156	59	9.96
65	60	100	80	160	60	10.2
68	62	102	84	164	61	10.44
71	64	104	88	168	62	10.68
74	66	106	92	172	63	10.92
77	68	108	96	176	64	11.16
80	70	110	100	180	65	11.4
83	72	112	104	184	66	11.64
86	74	114	108	188	67	11.88
89	76	116	112	192	68	12.12
92	78	118	116	196	69	12.36
95	80	120	120	200	70	12.6
98	82	122	124	204	71	12.84
101	84	124	128	208	72	13.08
104	86	126	132	212	73	13.32
107	88	128	136	216	74	13.56
110	90	130	140	220	75	13.8
113	92	132	144	224	76	14.04
116	94	134	148	228	77	14.28
119	96	136	152	232	78	14.52
122	98	138	156	236	79	14.76
125	100	140	160	240	80	15.0

TABLE II — T150 OUTPUT PRESSURES VS. TEMPERATURES

7E

TCS

PRODUCT DATA



Temperature Sensors

TCS/1000 series

ITEM NO. 7, 8
SUBMITTAL PARA. 1.4.1.C
PRODUCT PARA. 2.1.15.1

Description:

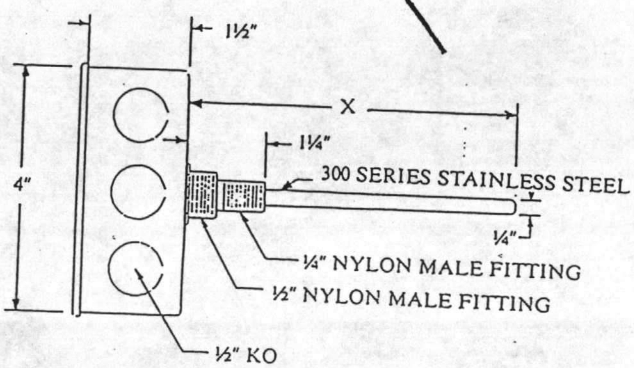
The TCS/1000 series temperature sensors provide accurate and reliable temperature measurement for building automation and control systems. Temperature sensors compatible with almost any control system are available including thermistors, RTD's, and integrated circuits. Standard mounting configurations are available for room, duct, immersion, strap-on, and outside air temperature sensing. All sensors are packaged for easy installation and effective long term operation.

TEMPERATURE CONTROL SPECIALTIES CO.
2800 Laura Lane · Middleton, Wisconsin 53562 · (608) 836-9034 · P.O. Box 350 · Madison, Wisconsin 53701

TCS

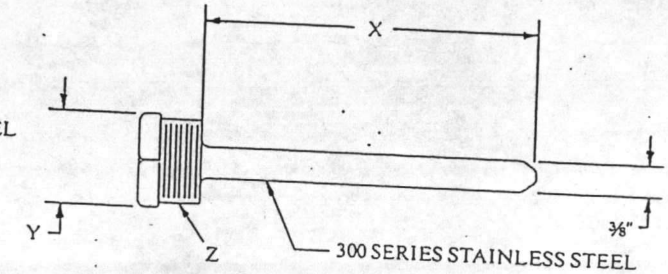
Dimensions

DUCT MOUNT



X: 4", 8", AND 12" PROBES AVAILABLE

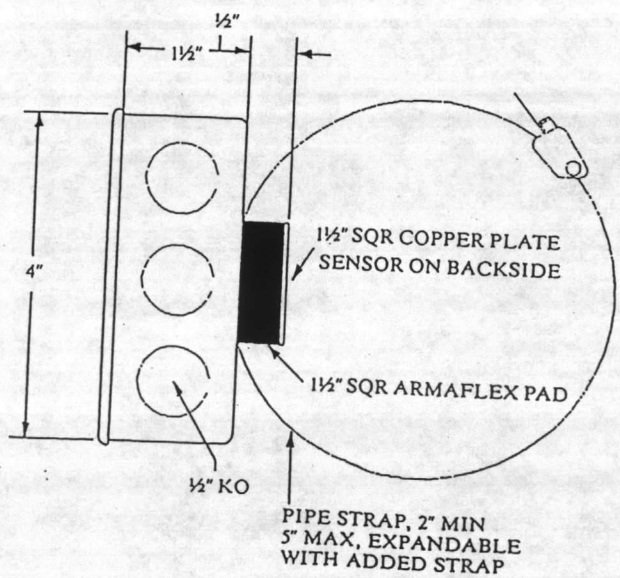
IMMERSION THERMOWELL*



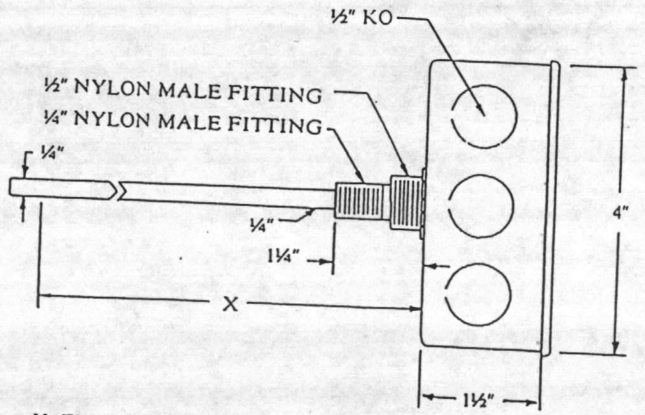
X: 8" OR 4" LENGTHS AVAILABLE
Y: 1⅛" FOR 8" IMMERSION
⅞" FOR 4" IMMERSION
Z: ¾" NPT FOR 8", ½" NPT FOR 4"

* included with Duct mount for Immersion models.

STRAP ON MOUNT



AVERAGING



X: FLEXIBLE COPPER SHEATH
12', 24' OR OTHER

PRODUCT DATA

Ordering Information: TCS/1000 — [ ] - [ ] - [ ]

Sensor:

- [1a] 100Ω Platinum, 2 wire
- [1b] 100Ω Platinum, 3 wire
- [1.5a] 500Ω Platinum, 2 wire
- [1.5b] 500Ω Platinum, 3 wire
- [2a] 1,000Ω Platinum, 2 wire
- [2b] 1,000Ω Platinum, 3 wire
- [3] 10,000Ω Thermistor
- [4] 1,000 ohm Nickel
- [5] 1,000 ohm Balco
- [6] 2,000 ohm Ni Fe
- [7] LM335 Semiconductor
- [8] AD592 Semiconductor
- [ ] Custom[3]

Enclosure:

- [R] Room
- [D] Duct (4″, 8″, or 12″ std.)
- [I] Immersion (4″ or 8″ std.)
- [S] Strap-on
- [O] Outside Air
- [A] Averaging[4] (12′ or 24′ std.)
- [W] Raw

Standard Probe Length:
e.g. [4″]

Note:
[3]Other sensors not listed are available, consult factory for system compatibility.
[4]Averaging sensors are available for 100Ω and 1000Ω platinum RTD's only.

10

TEMPERATURE CONTROL SPECIALTIES CO.
2800 Laura Lane · Middleton, Wisconsin 53562 · (608) 836-9034 · P.O. Box 350 · Madison, Wisconsin 53701

1200-3M 1087

ITEM NO. 9
SUBMITTAL PARA. 1.4.1.F
PRODUCT PARA. 2.1.13

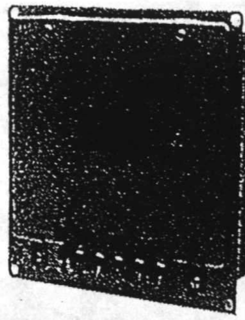
Enthalpy Selector

PNEUMATIC

APPLICATION

The Model H100 series enthalpy selector is a pneumatically operated energy conservation system designed for optimization of outside and return air usage in air handling systems. It measures airstream total heat (enthalpy) content and provides automatic two-position SPDT pneumatic switching action which may be utilized to provide the desired sequence of operation.

H100 Series



SPECIFICATIONS

Range: 20 to 45 BTU/lb. (46.8 to 105.4 kJ/kg) of dry air; standard 3 to 15 psig (21 to 103 kPa) output.
Supply Air Pressure: 20 psig (138 kPa).
Maximum Air Pressure: 30 psig (207 kPa).
Air Capacity: 1 cfm @ 15 psig supply (23.31 @ 103 kPa).
Differential: Switching differential of less than 1 BTU/lb. (2.3 kJ/kg) of dry air.
Mounting: Insertion chamber, flush with duct.
Connections: Barb fittings for 1/4" O.D. plastic tubing.
Dimensions: 8-3/8" high × 7-7/8" wide × 3" deep (213 mm × 200 mm × 76 mm).

MAINTENANCE PARTS

6-533 3/32" feedback ball for H102-101

TABLE 1. SPECIFICATIONS

Model No.	Description
H100-01	Basic O.A.-R.A. comparing system (two transmitters)
H100-02	O.A.-R.A. comparing system (one transmitter)
H100-03	Single transmitter O.A. system

TABLE 2. MAINTENANCE PARTS

Part No.	O.A. Transmitter	R.A. Transmitter	Switching Relay	Mounting Box
H100-01	H102-101	H102-101	R403-3	N5-50
H100-02		H102-101	R403-3	N5-50
H100-03	H102-101		R403-1	N5-50

TABLE 3. COMPETITIVE CROSS REFERENCE

Robertshaw Part No.	Barber-Colman	Honeywell	Johnson	Powers
H100-01	HKS-8065 (2) AK-52101	HP973A LP914A (2) HP971A (2)	N-9000 plus Sensors	RL243 plus Sensors
H100-02 H100-03	HKS-8065 AK-52101	HP973A LP-914A HP971A	N-9000 plus Sensors	RL-243 plus Sensors
H102-101	HKS-8065			

Note: Physical and functional difference exists between models. Review model specifications, applications and dimensions before selection of a replacement.

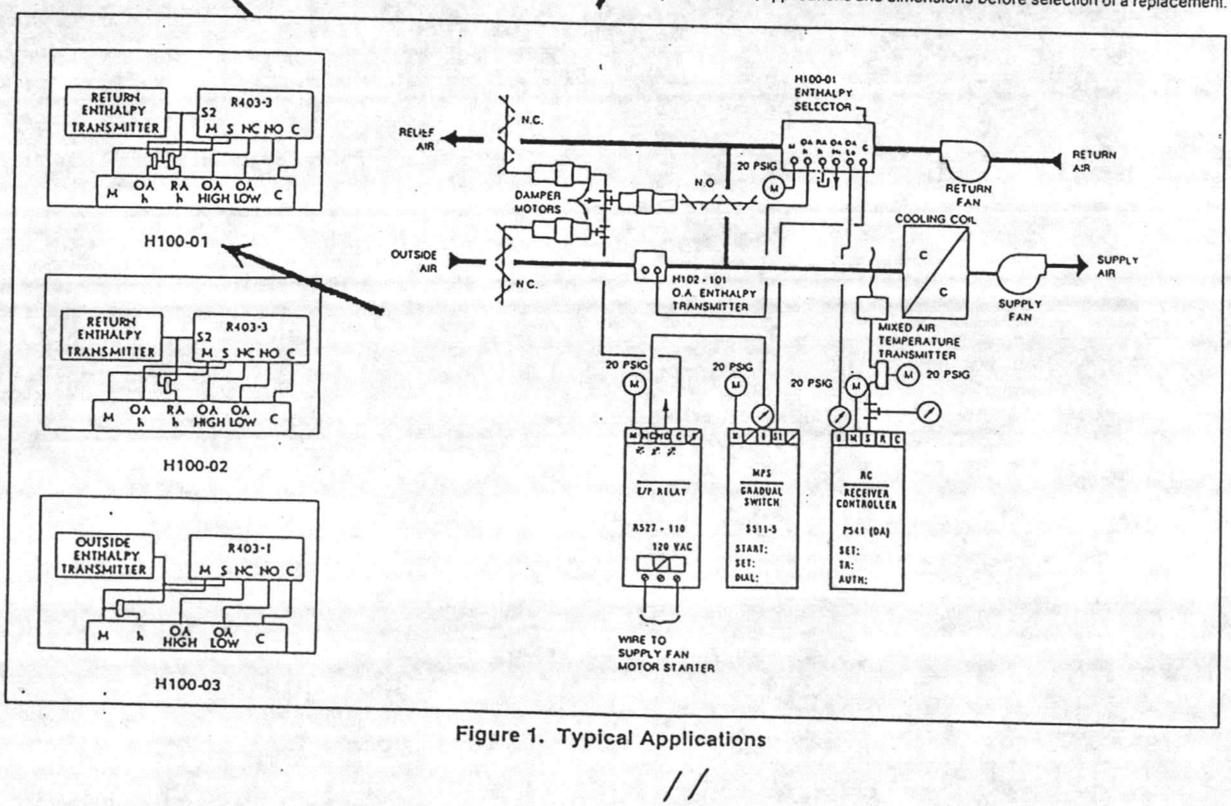


Figure 1. Typical Applications

ENTHALPY SELECTOR → H100 SERIES

Components of the Model H100 series of enthalpy selectors are packaged in boxes of a common size that are designed for mounting in sheet metal cut-outs in fan system ductwork. See Table I for quantity and location of duct boxes by model number.

TABLE I

MODEL	BOX QTY.	LOCATION	AIR PORTS	MAIN AIR CONN.
H100-01	2	Box "A" (enthalpy transmitter and comparing relay) in return air stream.	6	Yes
		Box "B" (enthalpy transmitter only[a]) in outside air stream. Must be representative location for all systems served (see H100-02).	2	No[b]
H100-02	1	In return air stream. Receives common O.A. enthalpy signal from box "B" of an H100-01).	6	Yes
H100-03	1	In outside air stream.	5	Yes

a - Transmitter is shipped in box "A" for on-site alignment of both transmitters, then moved to box "B."

b - If enthalpy signal must be transmitted more than 100 feet (30 m) total to return air boxes, connect main air to box "B" (fitting is provided) and add a transmitter restrictor inside box.

See Figure 1 for box and cut-out dimensions. Each box is attached to the duct surface with four sheet metal screws. Air connections are made through external barbed fittings.

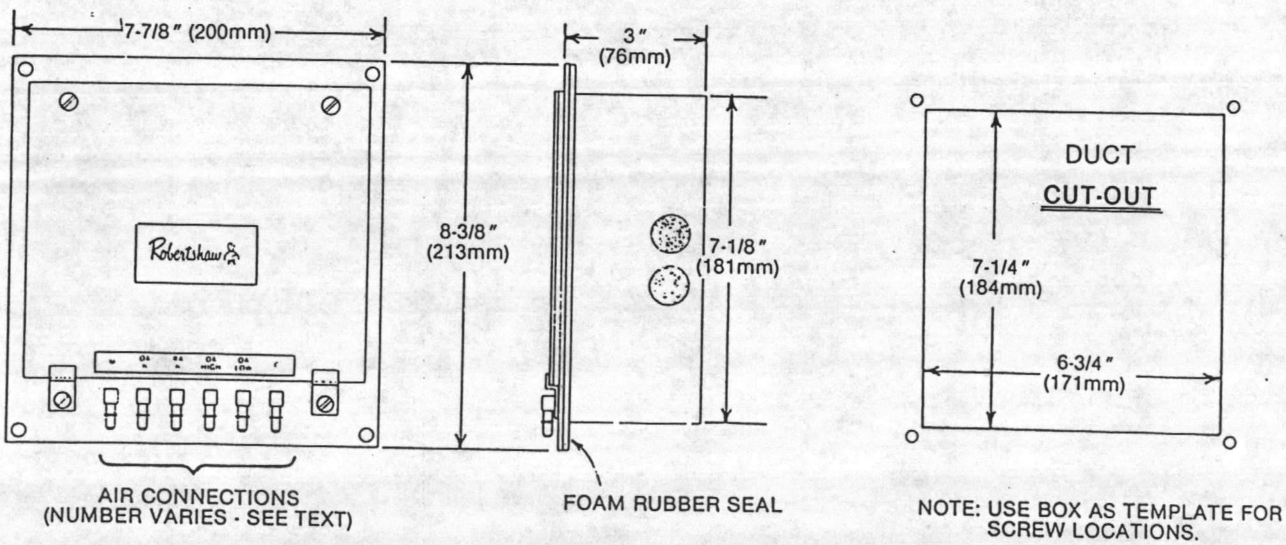


FIGURE 1 — H100 SERIES TYPICAL MOUNTING DIMENSIONS (H100-01 BOX "A" SHOWN).

11A

ENTHALPY SELECTOR → H100

GENERAL DESCRIPTION

The Model H100 series of enthalpy selectors are pneumatically operated, energy-conservation systems designed for the optimization of outside and return air usage in air handling systems to reduce mechanical cooling loads. In a standard application, the AHU damper controls are automatically switched so that the outside air intake can be increased (modulated) above a specified minimum flow *only* when its measured enthalpy (specific total heat content) is less than the measured return air enthalpy (Models H100-01 and H100-02) or less than a preset value representing the design return air enthalpy (Model H100-03). See Table I for model number descriptions. See Figure 2 for schematic diagrams of selector components and air connections.

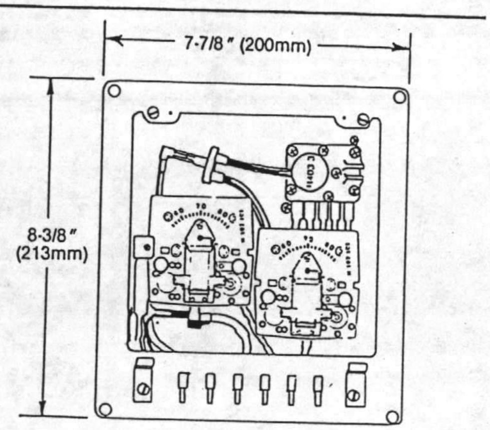


FIGURE 1 — INTERIOR VIEW OF H100-01 AS SHIPPED WITH BOTH TRANSMITTERS MOUNTED IN RETURN AIR SENSING CHAMBER.

TABLE I

MODEL (SYSTEM)	DESCRIPTION	COMPONENT DEVICES[a] LOCATION	FUNCTION	MODEL	APPLICATION
H100-01	O.A. - R.A. Comparing System	R.A. Box	Enthalpy Transmitter	H102-101	Damper control based on comparison of O.A. enthalpy to R.A. enthalpy.
			Differential Sw. Relay	R403-3	
		O.A. Box	Enthalpy Transmitter	H102-101	
H100-02	R.A. Comparing Unit	R.A. Box	Enthalpy Transmitter	H102-101	Used with common O.A. box (part of H100-01 on first AHU) for damper control based on comparison of O.A. enthalpy to R.A. enthalpy.
			Differential Sw. Relay	R403-3	
H100-03	O.A. Measuring Unit	O.A. Box	Enthalpy Transmitter	H102-101	Damper control based on comparison of O.A. enthalpy to set point.
			Adjustable Sw. Relay	R403-1	

a - See Calibration and Adjustment sections for component device descriptions.

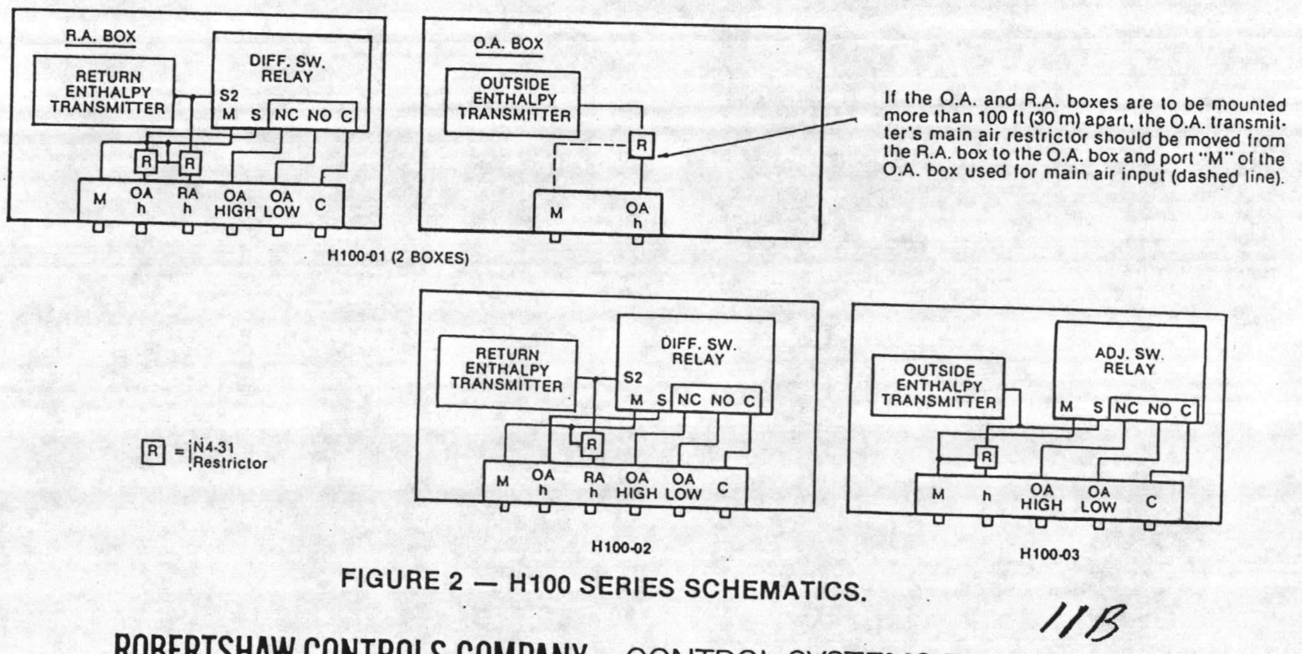


FIGURE 2 — H100 SERIES SCHEMATICS.

11B

CALIBRATION: ENTHALPY TRANSMITTER H102

The Model H102-101 enthalpy transmitter is designed to measure the enthalpy (specific total heat content) of an air stream and transmit a pneumatic signal (non-linear) to a control device and/or receiver gauge. It is factory-calibrated to output a 3 to 15 psig (21 to 103 kPa) signal for an enthalpy range of 20 to 45 BTU/lb (46.6 to 104.9 kJ/kg) of dry air (see Table II). It is a "one-pipe," force-balance transmitter which utilizes an external restrictor in its supply line. If the output pressure of the H102-101 does not correspond to Table II, check the following:

1. The air supply to the restrictor must be 20 psig ± 0.5 psi (138 kPa ± 3.5 kPa) and must be clean, dry and oil-free.
2. The restrictor and the device filter must be free of obstructions.

If, after completing the above checks, the transmitter output varies from Table II, see "Adjustment."

TABLE II — H102-101 OUTPUT PRESSURE VS. ENTHALPY

ENTHALPY BTU/LB	OUTPUT PSIG	WET BULB TEMP. °F[a]	ENTHALPY BTU/LB	OUTPUT PSIG	WET BULB TEMP. °F[a]
20	3.00	49.5	33	10.55	68.8
21	3.76	51.2	34	11.00	70.0
22	4.47	52.9	35	11.43	71.2
23	5.14	54.6	36	11.84	72.3
24	5.80	56.3	37	12.22	73.4
25	6.42	57.9	38	12.60	74.5
26	7.00	59.4	39	12.98	75.6
27	7.55	60.8	40	13.35	76.6
28	8.08	62.2	41	13.70	77.6
29	8.60	63.6	42	14.05	78.6
30	9.11	65.0	43	14.38	79.5
31	9.60	66.3	44	14.70	80.4
32	10.08	67.6	45	15.00	81.3

a - Enthalpy equivalent at 50% R.H.

ADJUSTMENT: ENTHALPY TRANSMITTER H102

NOTE: The Model H100-01 enthalpy selector is shipped with both H102-101 enthalpy transmitters mounted in the return air box (see Figure 1) to allow on-site alignment of the two transmitters to identical outputs for maximum accuracy. After alignment, the outside air unit is moved to its own O.A. box, but may be reinstalled in the R.A. box for comparison at any time.

Transmitter range adjustments may be accomplished as follows (see Figure 3):

1. Connect a suitable air pressure or enthalpy gauge into the output line. (Note that wet bulb temperatures provide a very close approximation to enthalpy values; see Table II).
2. Using thermostat wrench N2-4 (1/16" hex), turn the "calibration screw" to shift the output range (clockwise to decrease).
3. If output correction is not obtained, no other adjustment should be attempted and device replacement is necessary.

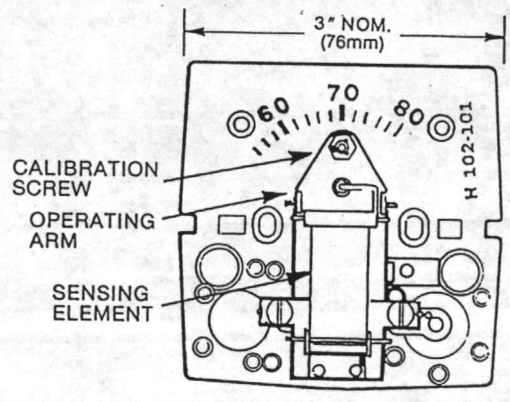


FIGURE 3 — H102-101 APPEARANCE.

11C

CALIBRATION: DIVERTING RELAY [ADJUSTABLE] R403-1

The Model R403-1 diverting relay is a snap-acting device designed to convert a proportional signal, at a predetermined setting, to a positive (two-position) pneumatic switching action. It is pilot-operated and requires a main air connection to port "M" of 15 to 25 psig (103 to 172 kPa). See Table III for description.

The R403-1 relay should not require field calibration; however, if it does not transfer port "NC" to "C" at its dial setting, it can be recalibrated by using a thermostat wrench N2-4 (1/16" hex) to turn the "calibrating screw" (see Figure 4, clockwise to increase).

TABLE III

MODEL	R503-1
TYPE	SPDT
DIFFERENTIAL	0.1 to 0.5 psi (0.7 to 3.5 kPa)
SET POINT RANGE	3* to 20 psig (21 to 140 kPa)
SWITCHING ACTION	Port SIG at set point minus diff.: ports NO & C are connected.
	Port SIG at set point: ports NC & C are connected.

* DO NOT SET below this value.
NOTE: Ports not connected to common (C) are blocked. On loss of main air pressure, ports NO & C will be connected regardless of SIG pressure.

ADJUSTMENT: DIVERTING RELAY [ADJUSTABLE] R403-1

The relay set point is changed by rotating the serrated set point adjustment knob (see Figure 4). The knob operates through two revolutions and the set point indicator shifts to indicate the effective portion of the concentric scales.

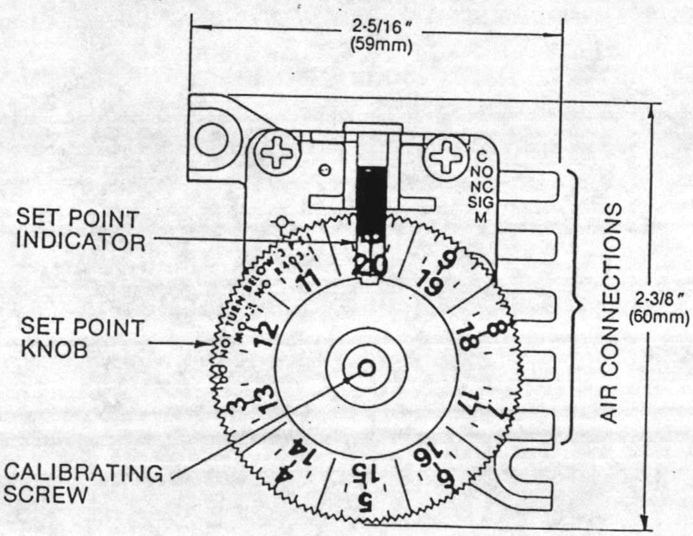


FIGURE 4 — R403-1 RELAY APPEARANCE.

11D

CALIBRATION: DIVERTING RELAY (DIFFERENTIAL) R403-3

The Model R403-3 is a non-adjustable, snap-acting, signal-comparing, diverting relay designed for use in pneumatic control systems where the application requires a pneumatic, two-position (SPDT) switching function based on the comparison of two proportional pneumatic input signals. A common application is control of mixed air dampers based on the comparison of signals from outside and inside enthalpy transmitters. The R403-3 is pilot-operated and requires a main air connection to port "M" of 15 to 25 psig (103 to 172 kPa). See Table IV for switching action. The R403-3 does not require calibration.

TABLE IV

MODEL	TYPE	MAIN AIR PRESSURE (PORT M)	SIGNAL PRESSURES (PORTS S & S2)	SWITCHING ACTION
R403-3	SPDT	15 to 25 psig (103 to 172 kPa)	S2 approx. 0.5 psi (3.4 kPa) greater than S	Ports NO & C connected
			S greater than or equal to S2	Ports NC & C connected
			None	Ports NC & C connected
		None	Any	Ports NO & C connected

NOTE: Port not connected to common (C) is blocked.

ADJUSTMENT: DIVERTING RELAY (DIFFERENTIAL) R403-3

The R403-3 is not adjustable. See Figure 5 for appearance.

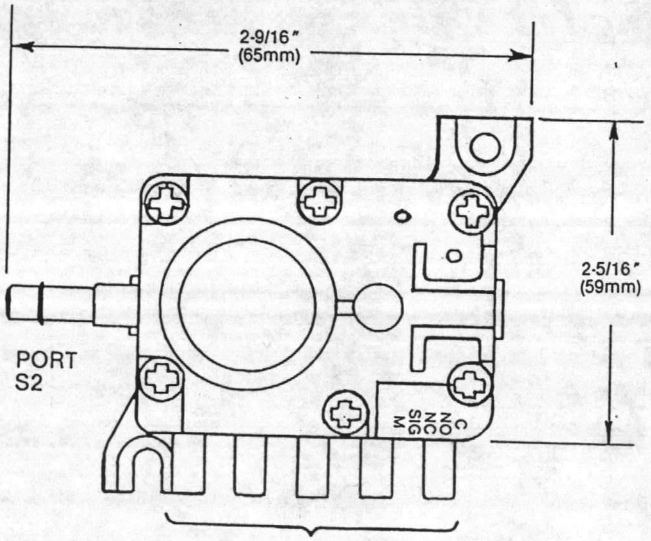


FIGURE 5 — R403-3 RELAY APPEARANCE.

2- & 3-WAY, DIRECT SOLENOID OPERATED, INLINE & MANIFOLD BASE

200 SERIES

MAC®

1/8" & 1/4"—C_V UP TO .5

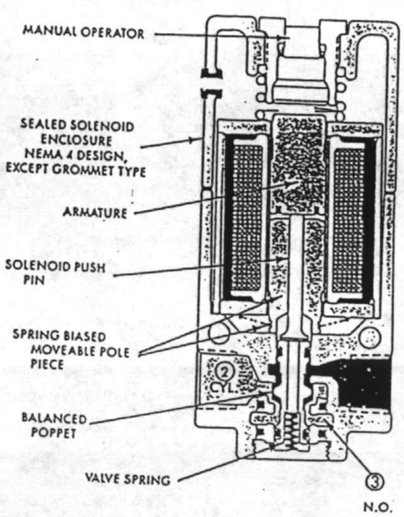
PRESSURE RANGE—VACUUM TO 150 PSI

PATENTS & PATENTS PENDING

SERIES FEATURES—DIRECT SOLENOID OPERATED VALVES

The Solenoid versions feature:

- The patented MACSOLENOID® with its non-burn out feature on AC service.
- Six valve functions with one Inline valve and four valve functions with one Manifold valve. See "Application Conversion Procedure" on this page.
- A triple rated coil for 120/60, 110/50 or 24 VDC (6 Watt).
- Inline & add-a-unit manifold capability.
- Use on lube or non-lube service.
- Extremely rapid response and cycle rate.
- Various types of manual operators and electrical enclosures.
- NEMA 4 solenoid enclosure except for grommet type.
- Extremely long service life.
- Optional low wattage DC solenoids down to 1 watt.



SOL. OPERATED, INLINE

VALVE CONFIGURATIONS AVAILABLE

The versatile 200 Series provides extremely fast shifting and long life in the following solenoid configurations.

- 3-way, Normally Open and Normally Closed.
- 2-way, Normally Open and Normally Closed.
- Inline or add-a-unit manifold.
- UL Listed and CSA Certified models available. See Section T-3.
- Optional N.C. only models for heavy air line contaminant applications (see "Special Applications" on this page).
- Optional Explosion Proof models for hazardous environments (see "Special Applications" on this page).

APPLICATION CONVERSION PROCEDURE:

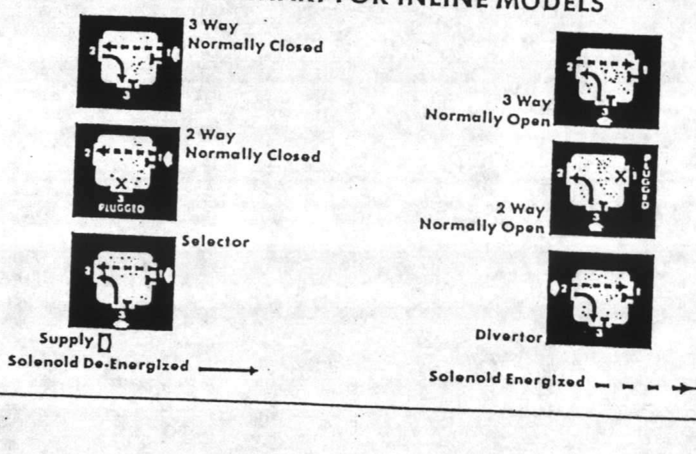
INLINE MODELS

The balanced poppet design facilitates using the same valve for 6 functions with any port being connected to vacuum, pressure or plugged. Piping is shown in the chart below.

MANIFOLD MODELS

The interchangeable function plate between the valve body and base permits selection for 2- or 3-way, Normally Closed or Normally Open operation, instead of through piping as shown below on the Inlines. On 3-way applications, one function plate is used for both N.C. and N.O. When "3-C" is visible on the plate, the function will be N.C. When "3-O" is visible, the function is N.O. On 2-way applications, a separate plate is used and like the 3-way plate is marked "2-C" for N.C. and "2-O" on the other side for N.O. The 2-way plates block the exhaust at the valve, permitting the mixing in a stack of 3-ways and 2-ways. Changes within a stack from one function to another can be made without disturbing the plumbing.

PIPING CHART FOR INLINE MODELS



SPECIAL APPLICATIONS:

N.C. ONLY MODELS

A single purpose Normally Closed Only model is available for those applications where a greater tolerance for heavy concentrations of water, compressor products and other air line contaminants is desired.

EXPLOSION PROOF MODELS

These models are designed to meet U.L. and C.S.A. standards for Division I, Class I, Groups B, C, D and Class II, Groups E, F, and G (NEMA equivalent to Class I is NEMA 7; Class II is NEMA 9). Explosion proof models are available in either inline or manifold versions but only with the no operator ("O") manual operator.

ITEM NO. 10
SUBMITTAL PARA. 1.4.1.G
PRODUCT PARA. 2.1.12

12

OPERATING DATA

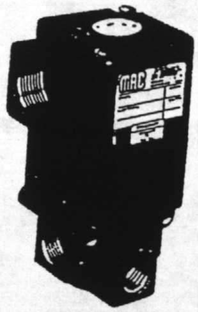
PRESSURE RANGE:	Vacuum to 150 PSIG	Pressures shown are minimum and maximum safe working pressures.
ORIFICE (ALL PORTS):	0.19" (4.8 mm)	
FLOW CONSTANT:	INLINE C_v=0.4 (1/8") 0.5 (1/4")	MANIFOLD =0.4
AMBIENT TEMPERATURE RANGE:	All valves rated 0°F to 140°F (−18° to 60°C). For UL purposes, maximum to 40°C (104°F).	

FLUIDS:	Air and inert gases
LUBRICATION:	Not required, but if lubrication is used, a medium aniline point oil is recommended.
ELECTRICAL: AC 120/60	Inrush 33.0 Volt-amps (.27 amps) Seal 19.7 Volt-amps (.16 amps)
DC 24 VOLT	8.5, 6.0, 2.5 or 1 watt
ABOVE COILS	General purpose Class A, cont. duty, encapsulated except 2.5 and 1 watt which are varnished.
LEADS	/18 AWG x 18" std.

HOW TO ORDER

200B SERIES

Select the desired model number from the tables below and add the desired voltage, manual operator and electrical enclosure to obtain complete model number, e.g.: 224B-111BA.



INLINE MODELS

MODEL NO. PORT SIZE NPTF 1/8" ③	1/4" ③	DESCRIPTION* (N.C. / N.O.)
224B-	225B-	Universal 2- or 3-Way (N.C. & N.O.)
274B-	275B-	N.C. Only 3-Way

MANIFOLD MODELS

MODEL NO. VALVE LESS BASE	DESCRIPTION* (CYL, IN EXH, N.C. / N.O.)		MODEL NO. VALVE WITH BASE NPTF ③ 1/8"	1/4"
250B-	Universal 3-Way (N.C. & N.O.)	Std. Sol.	256B-	257B-
		Exp. Proof Solenoid	258B-	259B-
260B-	Universal 2-Way (N.C. & N.O.)	Std. Sol.	266B-	267B-
		Exp. Proof Solenoid	268B-	269B-
280B-	N.C. Only 3-Way	Std. Sol.	286B-	287B-
		Exp. Proof Solenoid	288B-	289B-

*ANSI type symbols used.

MANIFOLD MODELS WITH REGULATOR

MODEL NO. VALVE LESS BASE	DESCRIPTION		MODEL NO. VALVE WITH BASE NPTF ③ 1/4"
250B-	3-Way	Selected Pressure Single Outlet-N.C. only	251B-
		Individual Pressure (N.C. & N.O.)	252B-
260B-	Universal 2-Way (N.C. & N.O.) Individual Pressure Only		262B-
280B-	3-Way N.C. Only Individual Pressure Only		282B-

③ For BSPP threads specify MOD 005 after complete model number; e.g., 224B-111BA MOD 005.

SOLENOID OPTIONS:

EXAMPLE: 225B-11 1 BA

XX	AC Voltage
11	120/60, 110/50 24 VDC (6W) ①
12	240/60, 220/50
22	24/50-60
26	480/60, 440/50

XX	DC Voltage
50	24 VDC (6.0W)
52	24 VDC (2.5W)
55	12 VDC (6.0W)
60	12 VDC (8.5W)
61	24 VDC (8.5W)

X	Manual Operators
0	No Operator
1	Non-Locking Recessed (Std.)
2	Locking Recessed
3	Non-Locking Extended
4	Locking Extended
5	No Operator with Light ①
6	Non-Locking Recessed w/Lgt. ①
7	Locking Recessed w/Lgt. ①
8	Non-Locking Extended w/Lgt. ①
9	Locking Extended w/Lgt. ①

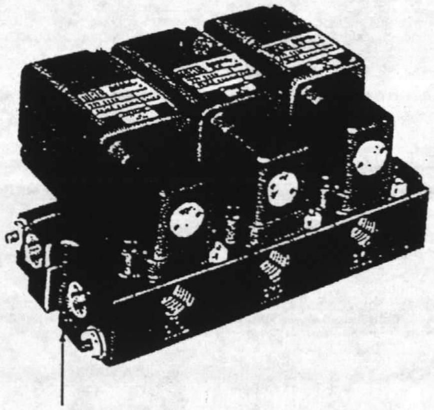
XX	Enclosure
AA	JIC w1/2" NPS Conduit
BA	Grommet
CA	Conduit 1/2" NPS
CC	Conduit ½" NPT (CSA Threads)
EA	Explosion Proof ②

Other AC & DC voltages available—DC wattages from 1.0 to 24 watts. See Section T-1 or consult factory.

External Plug-Ins available. See Section T-1 or Consult Factory.

① Lights are available for 120/60, 110/50 or 240/60, 220/50 or 24VDC with JIC enclosure only (AA). If -11 coil is used for 24VDC, specify MOD 472 for 24V light.

② Explosion proof enclosure supplied with No Operator only ("O"). Not available below 6 watt DC.



One end plate kit required per assembly. Order A2-5003-01 for NPTF threads or A2-5003-01P for BSPP threads.

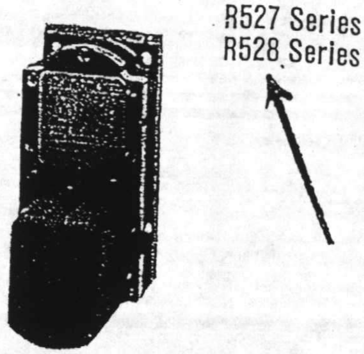
PNEUMATIC

APPLICATION

The R527 and R528 series electric-pneumatic relays are three-way, two-position, electrically activated air valves for use in pneumatic control systems where the application requires a variety of switching, diverting or interlocking functions, actuated by an electrical circuit. The R527 series switch one SPDT pneumatic circuit, while the R528 series are designed with DPDT pneumatic switching (two independent SPDT pneumatic circuits).

On the R527 series, when the coil is de-energized, ports C to NO are connected with port NC blocked. With the coil energized, ports C to NC are connected with port NO blocked.

On the R528 series, when the coil is de-energized, ports C to NO and C2 to NO2 are connected with ports NC and NC2 blocked. With the coil energized, ports C to NC and C2 to NC2 are connected with ports NO and NO2 blocked.



SPECIFICATIONS

Output: 3 to 15 psig.

Action:

SPDT Models (R527 series), Coil de-energized, C and NO are connected. Coil energized, C and NC are connected.

DPDT Models (R528 series), Coil de-energized, C and NO are connected, C2 and NO2 are connected. Coil energized, C and NC are connected, C2 and NC2 are connected.

Maximum Ambient Temperature: 140°F (60°C).

Supply Air Pressure: Clean, dry, oil free air required.

Nominal, 20 to 25 psig.

Maximum, 30 psig.

Connections:

Air, Barbed fittings for 1/4" O.D. polyethylene or 5/32" I.D. polyurethane tubing.

Electrical, Purchase separately the MCS-EC contact assembly with screw terminals and the MCS-EB electrical barrier.

Air Consumption: 1 scfh (28.8 scim).

Air Flow Capacity: 60 scfh.

Power Consumption: 2.2 VA.

Adjustments: Auto, manual switch.

Mounting: Designed for use on MCS-S manifold socket only.

Dimensions: 4-1/8" high × 1-1/32" wide × 2-55/64" deep (105 mm × 50 mm × 63 mm).

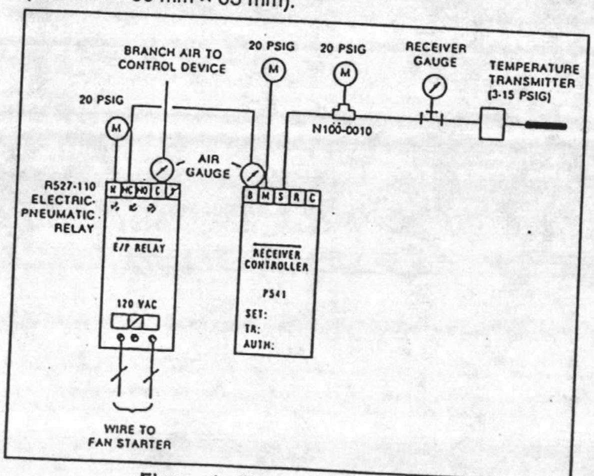


Figure 1. Typical Application

TABLE 1. SPECIFICATIONS

Model Number	Coil Voltage	Switch Action
R527-24 DC	24 Vdc	SPDT
R527-24	24 Vac	SPDT
R527-110	110 Vac	SPDT
R527-230	208-240 Vac	SPDT
R528-24 DC	24 Vdc	DPDT
R528-24	24 Vac	DPDT
R528-110	110 Vac	DPDT
R528-230	208-240 Vac	DPDT

TABLE 2. REPLACEMENT COILS

Model Number	Replacement Coil Description
K527-24	24 Vac
K527-110	110 Vac
K527-230	208-240 Vac
K527-24 DC	24 Vdc

TABLE 3. ACTIVE CONNECTIONS

Port	Connected to
M	Main air
C	Common
C2*	Common no. 2
NO	Normally open
NO2*	Normally open no. 2
NC	Normally closed
NC2*	Normally closed no. 2

*DPDT models only.
NOTE: A loss of main air pressure will have the same effect as de-energizing the coil.

TABLE 4. COMPETITIVE CROSS REFERENCE

Robertshaw Model No.	Recent Robertshaw	Barber-Colman	Honeywell	Johnson	Powers
R527			RP417B RP817B		
R528					
R527 w/ socket & enclosure	R427	AL-100 Series	RP417A RP817A	V-24	VE265

Note: Physical and functional difference exists between models. Review model specifications, applications and dimensions before selection of a replacement.

ACCESSORIES

MCS Series Pneumodular accessories

MAINTENANCE PARTS None

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ITEM NO. 11

SUBMITTAL PARA. 1.4.1.6

PRODUCT PARA: 2.1.12

CALIBRATION & ADJUSTMENT INSTRUCTIONS

PNEUMODULAR® ELECTRIC-PNEUMATIC RELAYS R527 R528

SINGLE & DUAL SWITCHING

CALIBRATION

The Model R527 series and R528 series electric-pneumatic relays are three-way, two-position, electrically activated air valves for use in pneumatic control systems where applications require a variety of switching, diverting or interlocking functions. The R527 series devices switch one SPDT pneumatic circuit. The R528 series devices simultaneously switch two SPDT pneumatic circuits for DPDT action. See Table I for model number descriptions and switching action.

The R527 and R528 relays are pilot-operated and require a main air connection to port "M" of 20 psig (138 kPa). They do not require calibration.

TABLE I

MODEL	COIL VOLTAGE	TYPE	SWITCHING ACTION	
			DE-ENERGIZED ("NORMAL")	ENERGIZED
R527-24	24 VAC	SPDT	Ports NO & C connected	Ports NC & C connected
R527-24DC	24 VDC			
R527-110	115 VAC			
R527-230	208-240 VAC			
R528-24	24 VAC	DPDT	Ports NO & C connected; ports NO2 & C2 connected	Ports NC & C connected; ports NC2 & C2 connected
R528-24DC	24 VDC			
R528-110	115 VAC			
R528-230	208-240 VAC			

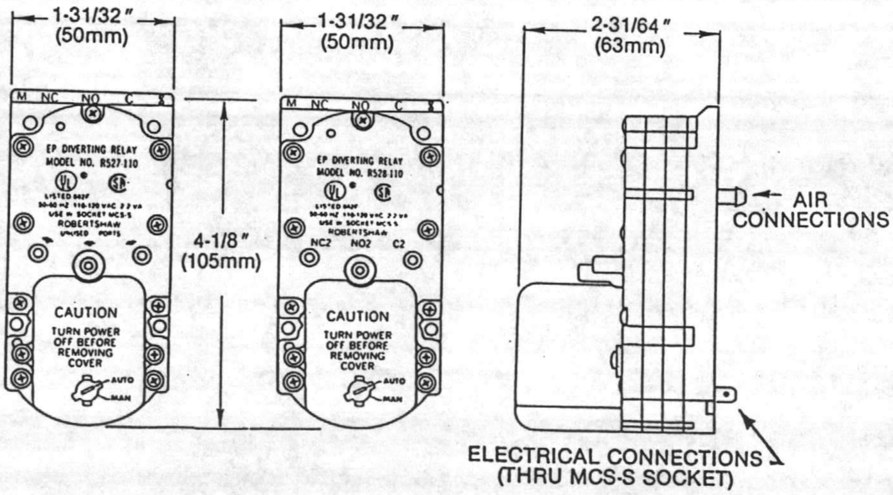
On all models, ports not connected to Common (C) or (C2) are blocked.
On all R528 models, both pneumatic switching circuits are activated simultaneously.

ADJUSTMENT

The R527 and R528 electric-pneumatic relays do not require adjustment.

Manual Operation: These relays feature a slotted "AUTO-MAN" switch (automatic and "on" positions) on their covers to permit manual system operation when electrical power is not connected.

Coil Replacement: Replacement relay solenoid coils are listed in Table II. The replacement procedure is as follows:



R527 SERIES   R528 SERIES   TYPICAL

FIGURE 1 - ELECTRIC-PNEUMATIC RELAY APPEARANCE

1. Remove the two cover screws and the solenoid cover.
2. Loosen the coil mounting screw and lift the coil from its mounting post.
3. Remove the relay wire "quick connect" lugs from the coil terminals.
4. Reverse the above procedure to install the new coil, making sure that the projection on the back of the coil frame is firmly seated in its relay body detent. The clearance between the relay leakport and the solenoid leakport plug must be 0.005 to 0.008 inches (0.13 to 0.20mm) when the relay is de-energized.

TABLE II

MODEL	COIL VOLTAGE
K527-24	24 VAC
K527-24DC	24 VDC
K527-110	115 VAC
K527-230	208-240 VAC

Robertshaw

ITEM NO. 12
SUBMITTAL PARA. 1.4.1.6
PRODUCT PARA. 2.1.12

DATA SHEET

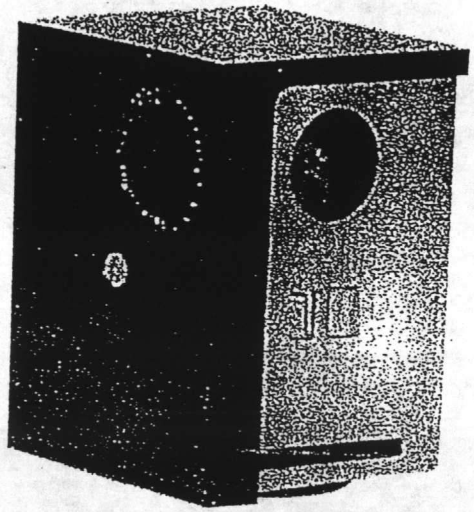
R471

PNEUMATIC ELECTRIC RELAY

GENERAL DESCRIPTION

The R471 Pneumatic-Electric Relays are used in control systems requiring conversion of gradual air pressure changes to positive electrical switching actions. Typical applications are starting/stopping unit ventilator and fan coil motors, unit heaters, and air handling unit fans.

The R471 incorporates a non-metallic diaphragm that is displaced by air pressure changes. The diaphragm in turn actuates a heavy duty electrical contact mechanism.



UL UNDERWRITERS' LABORATORIES LISTED

SPECIFICATIONS

MODEL NUMBER: R471-1

CONTROL SWITCHING ACTION: Three wire, single pole, double throw.

AIR CONNECTION: 3/16" (4.76) Nipple for 1/4" (6.35) Tubing

SET POINT RANGE: 3 to 25 psig (13.79 to 172.4 kPa)

MAXIMUM PRESSURE: 30 psig (206.8 kPa)

DIFFERENTIAL: 2.0 psi Fixed (13.79 kPa)

AMBIENT TEMPERATURE: 32° to 140°F (0° to 60°C)

CONDUIT OPENING: 1/2" Conduit size, both sides of housing.

ELECTRICAL RATING:
21 Amps non-inductive @ 120-240-480 VAC
1 HP @ 120 VAC
2 HP @ 240 VAC

ORDERING INFORMATION: SPECIFY: Model Number

ORDER FROM:
Local Office of
CONTROL SYSTEMS DIVISION
ROBERTSHAW CONTROLS COMPANY
or office noted below.

GENERAL INSTRUCTIONS

1. Use on control air only.
2. This relay will operate mounted in any position.
3. Any electrical loads exceeding the relay's rating should be controlled by intermediate relays, contactors or motor starters.

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ROBERTSHAW CONTROLS COMPANY • CONTROL SYSTEMS DIVISION 1800 GLENSIDE DRIVE P. O. BOX 27606 • RICHMOND, VIRGINIA 23261

CALIBRATION & ADJUSTMENT INSTRUCTIONS

PNEUMATIC-ELECTRIC RELAYS

R471
R472

CALIBRATION

Model R471 and R472 pneumatic-electric relays are used in pneumatic control system applications requiring conversion of gradual air pressure changes to positive electrical switching action.

The R471-1 relay has single-pole, double-throw switching action; the R472-1 has double-pole, double-throw action. These relays should be operated by control air only with a maximum pressure of 30 psig (207 kPa). Electrical ratings are listed in Table I.

These relays are not factory calibrated.

TABLE I

ELECTRICAL RATING (EACH SWITCH)
21 Amps non-inductive @ 120-240-480 VAC
1 HP @ 120 VAC
2 HP @ 240 VAC

ADJUSTMENT

The switching **differential** of these relays is not adjustable. It is fixed at approximately 2 psi (14 kPa) for the R471 and 3 psi (21 kPa) for the R472.

The **setpoint** ranges of these relays are as follows:

R471-1 (SPDT): 2 to 25 psig (14 to 172 kPa)
R472-1 (DPDT): 4 to 20 psig (28 to 138 kPa)

The device setpoint may be adjusted by removing the enclosure cover (retained by a slotted screw in the front of the cover) and then rotating the adjustment disc until the bottom surface of the disc is aligned with the desired value on the adjacent pressure scale (see Figure 1). For maximum accuracy, the switch points should be measured with a pressure gauge in the signal line.

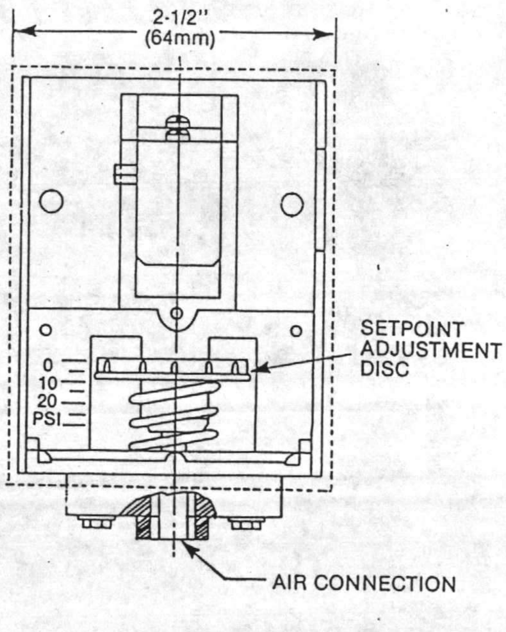
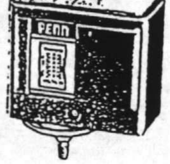


FIGURE 1 — TYPICAL RELAY APPEARANCE (MODEL R471 SHOWN).

15A

P67 SERIES LOW PRESSURE

LOW AND LINE VOLTAGE — RANGE 3 TO 30 PSIG



SERIES P67

These two pole controls are designed for applications where air pressure operates an electric device. Typical uses include control of air compressors, fans, pilot lights, etc.

Double pole, single break models are supplied in both normally open and normally closed constructions. A four-wire, two circuit block permits the main contacts to open; simultaneously closing the auxiliary contacts.

Pressure element has ¼" male NPT connector. Non-metallic diaphragm is positioned by air pressure. Range and differential settings are field adjustable.

TO ORDER: Specify Catalog Number only.

Catalog Number	Control Action	Scale Range* psig (kPa)	Differential psi (kPa)	Shipping Wt. Lbs.
P67AA-1	DPST — Opens on Pressure drop	3 to 30 (21 to 207)	1½ - 20 (10 to 138) Adjustable	1.7
P67CA-1	DPST — Opens on Pressure rise			
P67EA-5	L-M2 contacts make on pressure rise — simultaneously the L-M1 contacts break			
P67FA-5	L-M2 contacts break on pressure rise — simultaneously the L-M1 contacts make			

* Range is minimum cutout to maximum cut-in on "Open Low" controls. It is minimum cut-in to maximum cutout on "Open High" controls.

ELECTRICAL RATINGS

P67AA, P67CA

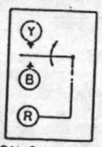
Motor Ratings	1 Phase				2 - 3 Phase		
	120 V.	208 V.	240 V.	277 V.	208 V.	240 V.	277 V.
A.C. Full Load Amps.	12.0	12.0	12.0	—	12.0	12.0	—
A.C. Locked Rotor Amps.	72.0	72.0	72.0	—	72.0	72.0	—
A.C. Non-Ind. Amps.	12.0	12.0	12.0	12.0	—	—	—
D.C. Non-Ind. Amps.	3.0	0.5	0.5	—	—	—	—
Pilot Duty — 125 VA., 120-600 V. A.C.; 57.5 VA., 120/300 V. D.C.							

P67EA, P67FA

Pole Number	LINE-M2 (Main)				LINE-M1 (Auxiliary)			
Motor Rating	120V.	208V.	240V.	277V.	120V.	208V.	240V.	277V.
A.C. Full Load Amps.	16.0	9.2	8.0	—	6.0	3.3	3.0	—
A.C. Locked Rotor Amps.	96.0	55.2	48.0	—	36.0	19.8	18.0	—
A.C. Non-Ind. Amps.	16.0	9.2	8.0	7.2	6.0	6.0	6.0	6.0
Pilot Duty — Both Poles: 125 VA., 24 to 600 V. A.C.; 57.5 VA., 120 to 300 V. D.C.								

P74 SERIES DIFFERENTIAL PRESSURE CONTROL

Type P74JA



ACTION ON INCREASE OF PRESSURE DIFFERENTIAL

This differential pressure control is commonly used on water systems to maintain a constant pressure difference between supply and return lines. SPDT contacts position a Series M80 or M81 motor actuated valve located in a by-pass line around the system pump.

A change in pressure at either control element will reposition the switching mechanism to cause corrective action of supplementary control equipment.

Features include:

— Field proven Pennswitch with completely enclosed contact mechanism.

— Pressure differential setting easily changed without removing cover.

— Universal mounting bracket supplied.

TO ORDER: Specify Catalog Number only.

Series P74

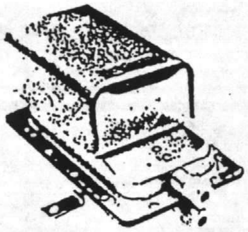
Catalog Number	Pressure Differential Range psig (kPa)	Connector Size	Switch Action	Electrical Rating	Switch Differential	Maximum Overrun Pressure psig (kPa)
P74FA-1	8 to 60 (55 to 414)	¼" Male	SPDT Snap-Acting	6 Amperes 120 volt, 50/60 Hz	2 psi (14 kPa)	180 (1241)
P74FA-5		¼" FNPT	SPDT Snap-Acting	6 Amperes 120 volt, 50/60 Hz		
P74JA-2		¼" Male	SPDT Floating	1 Ampere 24 volt, 50/60 Hz		

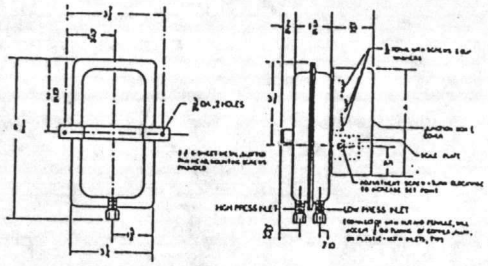
ITEM NO. 13
SUBMITTAL PARA. 1.4.1.6
PRODUCT PARA. 2.1.15.2

16

RH-3 AIR FLOW SWITCH

Columbus Electric

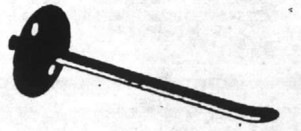


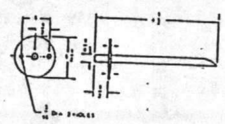


ITEM NO. 14
SUBMITTAL PARA. 1.4.1.G
PRODUCT PARA. 2.1.15.2

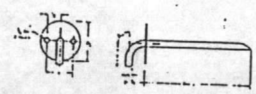
Adjustable in the range from .05" ± 0.2 W.C. to 12.0" ± .1 W.C. May be used to sense low pressure or vacuum or differentials of pressure or vacuum. Typical applications are to prove blower operation in electric duct heater installations; to sense dirty filters; prove blower operation for humidification; signal build-up of frost, operate Air Cleaners in Heat-Pump Installation. Electrical Rating - 15 Amps @ 125 VAC Resistive ¼ Hp 125 VAC, ½ Hp 250 VAC, 300 VA 277 VAC, 490 VA @ 250 VAC, U.L. Listed - File #MH-10196. Temperature rating −40° to 180°F.

PITOT TUBES





Model No. 1729



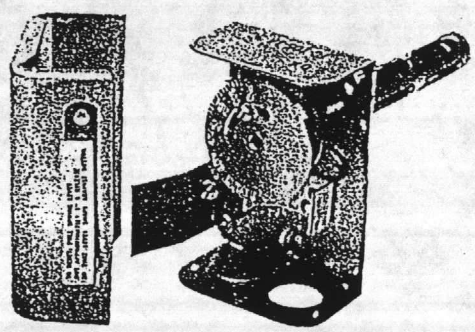
Model No. 1730

DUCT MOUNTED FIRESTAT

Columbus Electric

ORDERING CODE:
TC-108-1A-3C-ADJUSTABLE SETTING

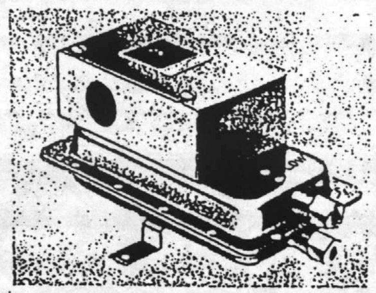
HELIX BIMETAL SENSES SUDDEN INCREASE IN DUCT TEMPERATURE SUCH AS IN A FIRE AND OPERATES TO TURN OFF THE BLOWER. ELECTRICAL CAPACITY 3/4 HP 125 VAC. AVAILABLE IN 7½ ELEMENT LENGTH. MANUAL RESET BUTTON. SETTING IS FIELD ADJUSTABLE THROUGH 100° - 250° RANGE. U.L. LISTED



AFS-222 AIR-SENSING SWITCH

Cleveland Controls

AFS-222 IS A GENERAL PURPOSE AIRFLOW PROVING SWITCH DESIGNED FOR HVAC AND ENERGY MANAGEMENT APPLICATIONS. IT MAY BE USED TO SENSE POSITIVE, NEGATIVE OR DIFFERENTIAL PRESSURE. THE PLATED HOUSING CONTAINS A DIAPHRAGM, A CALIBRATION SPRING AND A SNAP-ACTING SPDT SWITCH. SAMPLE CONNECTIONS LOCATED ON EACH SIDE OF THE DIAPHRAGM ACCEPT ¼" OD TUBING. AN ENCLOSURE COVER GUARDS AGAINST CONTACT WITH THE LIVE SWITCH TERMINAL SCREWS AND THE SET POINT ADJUSTING SCREW.



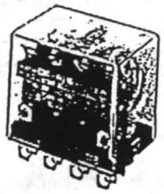
APPLICATION

Enclosed, square base, plug-in relay.

P-125 Series
P-127 Series
P-128-2-M

ITEM NO. 15
SUBMITTAL PARA. 1.4.1.6
PRODUCT PARA. 2.3.2

P-125 Series
P-127 Series



P-128-2-M

TABLE 1. SPECIFICATIONS

Part No.	Contacts	Coil	Std. Pkg. Quantity	Use with Socket Part No.	Terminals	Std. Pkg. Quantity
P-125-1-3	SPDT	24 Vac 2 VA	1	P-100-4	11 Square	1
P-125-2-3	SPDT	120 Vac 2 VA	1	P-100-4	11 Square	1
P-127-1-4	3PDT	24 Vac 2.2 VA	1	P-100-4	11 Square	1
P-127-2-4	3PDT	120 Vac 2.2 VA	1	P-100-4	11 Square	1
P-127-4-4	3PDT	24 Vdc 1.2 W	1	P-100-4	11 Square	1
P-127-7-4	3PDT	240 Vac 2.2 VA	1	P-100-4	11 Square	1
P-128-2-M	4PDT	120 Vac 2.2 VA	1	P-110-8-M	14 Square	1

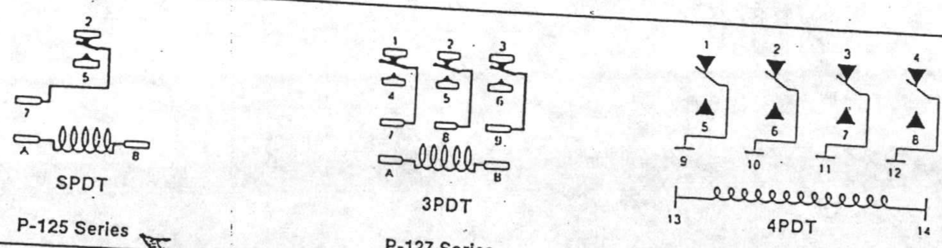
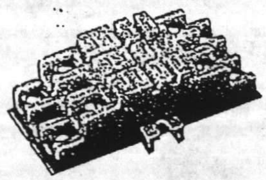


Figure 1. Wiring Diagrams

PURCHASED MATERIAL

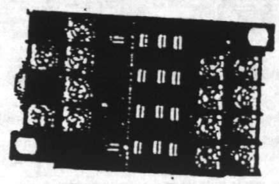
P-10X-4 SOCKETS

For P-125 series and P-127 series relays. May be surface mounted or track mounted using P-605 (P-100-4) or P-610 (P-101-4) mounting tracks.



P-110-8-M SOCKET

For P-128-2-M relay. May be base mounted or track mounted using P-610 mounting track.



See next page for mounting track information

ITEM NO. 16
SUBMITTAL PARA. 1.4.1.H
PRODUCT PARA. 2.1.11.1

7 AND 365-DAY TIMERS

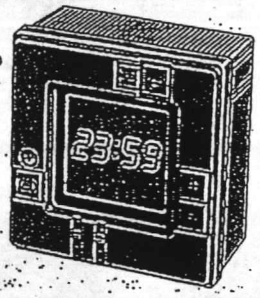
ELECTRONIC, 7-DAY, PROGRAMMABLE, 2-CHANNEL TIMER

- Programming for 24 hours, 7 days a week using five programming keys
- 16 program steps and cycle operation available
- Power supply range: 100 to 240VAC, 50/60 Hz
- Two independent 15A control circuits
- Manual On-Off switching for each control output without changing program
- 10-Year memory protection by built-in battery
- Easy-To-Read, 0.5" high LCD time display
- Surface, track (DIN type mounting track see Stock No. Cross Reference Guide under No. 6X295), and flush mounting. Fits 1/4 DIN panel cutout; measures 3¼H x 3¼W x 2¼"D

OMRON

UL E52800

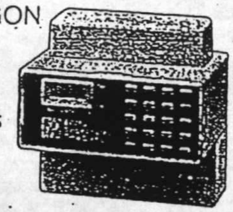
CSA LR22310



ELEC. SPECIFICATIONS					TIMER SPECIFICATIONS				ORDERING DATA				
	Contact Load Rating @ 60 Hz, Resistive				Timer Setting		Minimum Cycle Interval	Max. Daily On/Off Operations/ Pole	Omron Model	Stock No.	Available Lot Pricing		Shpg. Wt.
No. of Poles	Form	125VAC	250VAC	30VDC	Min.	Max.					List	Each	
2	SPST	15A	10A	10A	00:01	23:59 (hours: min.)	1 minute between On-Off periods	16	H5L-A	4A342			1.1

ELECTRONIC, 365-DAY, PROGRAMMABLE, 1 AND 2-CHANNEL TIMERS

PARAGON



EC71D SERIES

UL E10597

CSA LR8376-305

1-CHANNEL TIMER

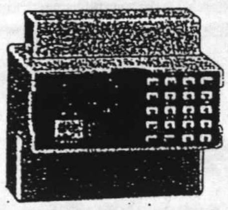
- Single channel SPDT
- 18 On-Off/Momentary set points
- 7-day programming—plus an eight day holiday using 365 day calendar
- 11 holiday durations programmable by date
- Manual override through keyboard
- 100 hour battery carry-over which maintains programming during power outages
- Surface or DIN rail mountable

ELECTRICAL SPECIFICATIONS					TIMER SPECIFICATIONS			ORDERING DATA			
	Contact Load Rating @ 120 VAC, 60 Hz										
No. Poles	Form	Max. Amps/Pole, Resistive	Pilot Duty 120/240VAC	Timer Power @ 60 Hz	Time Settings Min.	Max.	Max. Daily ON and OFF Operations/ Pole	Stock No.	Lot Prices Available List	Each	Shpg. Wt.
1	SPDT	15/15	345VA	100-120	1	365 days	9	5A685			1.5

2-CHANNEL TIMER

- 2 channel with independent programming for each circuit
- 365-day programming with 12 single holidays and 2 holiday durations
- Momentary feature with preset duration of 2 seconds
- Pushbutton programming
- Holiday programming for 12 holidays
- 100 hours of battery carry-over which maintains program during power failure
- Manual override through keyboard
- Built-In line filtering for electronic circuitry, preventing normal line disturbances from altering the program
- Surface or DIN rail mountable

PARAGON



EC72D SERIES

No. 2A516

ELECTRICAL SPECIFICATIONS					TIMER SPECIFICATIONS			ORDERING DATA			
	Contact Load Rating @ 120 VAC, 60 Hz.										
No. Poles	Form	Max. Amps/Pole, Resistive	Pilot Duty 120/240VAC	Timer Power @ 60 Hz	Time Settings Min.	Max.	Max. Daily ON and OFF Operations/ Pole	Stock No.	Lot Prices Available List	Each	Shpg. Wt.
2	SPDT	15/15	345VA	100-120	1	365 days.	8	2A516			1.2

TELL US WHAT YOU NEED—WE'LL DO OUR BEST TO HELP YOU!

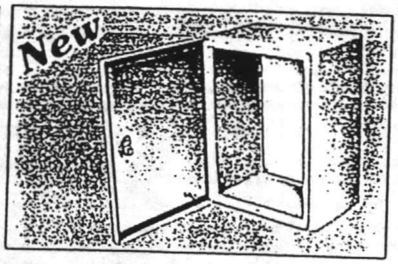
SEE WARRANTY INFORMATION ON INSIDE BACK COVER

SINGLE DOOR NEMA TYPE 4, TYPE 12, AND TYPE 13 ENCLOSURES

BULLETIN A-12

Hoffman® BRAND ENCLOSURES © February 1988

A



APPLICATION

Designed to house electrical and electronic controls, instruments, and components in indoor or outdoor areas where dirt, dust, oil, water, or other contaminants are present. Smooth, blended surfaces and attractive finish complement high tech electronic equipment.

CONSTRUCTION

- 16 gauge, 14 gauge, or 12 gauge steel
- Seams continuously welded and ground smooth
- Body stiffeners in larger enclosures for extra rigidity
- Doors are interchangeable and easily removable by pulling hinge pins
- Grounding studs welded to door and body assures positive ground

Table A.8

STANDARD SIZES

Enclosure Catalog Number	Body Gauge	Door Gauge	Enclosure Size AxBxC	*Panel Catalog Number	Panel Size DxE	Center Stiffener	F	G	H
★ A-L12H1206LP	16	14	12.00x12.00x6.00 (305x305x152)	A-12DLP12	9.00x9.00 (229x229)	Not Included	6.00 (152)	–	–
★ A-L16H1206LP	16	14	16.00x12.00x6.00 (406x305x152)	A-16P12	13.00x9.00 (330x229)	Not Included	8.00 (203)	–	–
★ A-L16H1606LP	16	14	16.00x16.00x6.00 (406x406x152)	A-16P16	13.00x13.00 (330x330)	Not Included	8.00 (203)	–	–
★ A-L20H1606LP	16	14	20.00x16.00x6.00 (508x406x152)	A-20P16	17.00x13.00 (432x330)	Not Included	10.00 (254)	–	–
★ A-L20H2006LP	16	14	20.00x20.00x6.00 (508x508x152)	A-20P20	17.00x17.00 (432x432)	Not Included	10.00 (254)	–	–
★ A-L20H1608LP	16	14	20.00x16.00x8.00 (508x406x203)	A-20P16	17.00x13.00 (432x330)	Not Included	10.00 (254)	–	–
★ A-L24H1608LP	16	14	24.00x16.00x8.00 (610x405x203)	A-24P16	21.00x13.00 (533x330)	Not Included	12.00 (305)	–	–
★ A-L16H2008LP	16	14	16.00x20.00x8.00 (406x508x203)	A-20P16	17.00x13.00 (432x330)	Not Included	8.00 (203)	–	–
★ A-L20H2008LP	16	14	20.00x20.00x8.00 (508x508x203)	A-20P20	17.00x17.00 (432x432)	Not Included	10.00 (254)	–	–
★ A-L24H2008LP	16	14	24.00x20.00x8.00 (610x508x203)	A-24P20	21.00x17.00 (533x432)	Not included	12.00 (305)	–	–
★ A-L30H2008LP	14	14	30.00x20.00x8.00 (762x508x203)	A-30P20	27.00x17.00 (686x432)	Not Included	4.00 (102)	22.00 (559)	–
★ A-L20H2408LP	16	14	20.00x24.00x8.00 (508x610x203)	A-24P20	21.00x17.00 (533x432)	Not included	10.00 (254)	–	–
★ A-L24H2408LP	14	14	24.00x24.00x8.00 (610x610x203)	A-24P24	21.00x21.00 (533x533)	Not Included	4.00 (102)	16.00 406)	–
★ A-L30H2408LP	14	14	30.00x24.00x8.00 (762x610x203)	A-30P24	27.00x21.00 (686x533)	Not included	4.00 (102)	22.00 (559)	–
★ A-L36H2408LP	14	14	36.00x24.00x8.00 (914x610x203)	A-36P24	33.00x21.00 (838x533)	Not Included	4.00 (102)	28.00 (711)	–
★ A-L24H3008LP	14	14	24.00x30.00x8.00 (610x762x203)	A-30P24	27.00x21.00 (686x533)	Not Included	4.00 (102)	16.00 (406)	–
★ A-L30H3008LP	14	12	30.00x30.00x8.00 (762x762x203)	A-30P30	27.00x27.00 (686x686)	Not Included	4.00 (102)	22.00 (559)	7.00 (178)
★ A-L36H3008LP	14	12	36.00x30.00x8.00 (914x762x203)	A-36P30	33.00x27.00 (838x686)	Not Included	4.00 (102)	28.00 (711)	9.00 (229)
★ A-L20H2012LP	16	14	20.00x20.00x12.00 (508x508x305)	A-20P20	17.00x17.00 (432x432)	Not Included	10.00 (254)	–	–
★ A-L24H2412LP	14	14	24.00x24.00x12.00 (610x610x305)	A-24P24	21.00x21.00 (533x533)	Not included	4.00 (102)	16.00 (406)	–
★ A-L30H2412LP	14	14	30.00x24.00x12.00 (762x610x305)	A-30P24	27.00x21.00 (686x533)	Not Included	4.00 (102))	22.00 (559)	–
★ A-L36H3012LP	14	12	36.00x30.00x12.00 (914x762x305)	A-36P30	33.00x27.00 (838x686)	Not Included	4.00 (102)	28.00 (711)	9.00 (229)
★ A-L36H3612LP	14	12	36.00x36.00x12.00 (914x914x305)	A-36P36	33.00x33.00 (838x838)	Not Included	4.00 (102)	28.00 (711)	9.00 (229)
★ A-L42H3612LP	14	12	42.00x36.00x12.00 (1067x914x305)	A-42P36	39.00x33.00 (991x838)	Included	21.00 (533)	–	9.88 (251)
★ A-L48H3612LP	14	12	48.00x36.00x12.00 (1219x914x305)	A-48P36	45.00x33.00 (1143x838)	Included	24.00 (610)	–	11.38 (289)
★ A-L60H3612LP	14	12	60.00x36.00x12.00 (1524X914x305)	A-60P36	57.00x33.00 (1448x991)	Included	30.00 (762)	–	14.38 (365)
★ A-L24H2416LP	14	14	24.00x24.00x16.00 (610x610x406)	A-24P24	21.00x21.00 (533x533)	Not Included	4.00 (102)	16.00 (406)	–
★ A-L36H3016LP	14	12	36.00x30.00x16.00 (914x762x406)	A-36P30	33.00x27.00 (838x686)	Not Included	4.00 (102)	28.00 (711)	9.00 (229)
★ A-L48H3616LP	14	12	48.00x36.00x16.00 (1219x914x406)	A-48P36	45.00x33.00 (1143x838)	Included	24.00 (610)	--	11.38 (289)

Millimeter dimensions ( ) are for reference only; do not convert metric dimensions to inch.
* Panels must be ordered separately.
★ NEW CATALOG ITEMS.

ITEM NO. 17

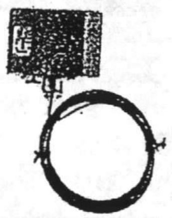
SUBMITTAL PARA. 1.4.1.I

PRODUCT PARA. 2.1.14

ELECTRIC/ELECTRONIC

Low Temperature Thermostats

TC-5131
TC-5141



APPLICATION

For low or line voltage low temperature control in ducts.

SPECIFICATIONS

Setpoint Dial Range: 34 to 60°F (1 to 16°C).
Sensing Element: Vapor pressure type, copper construction.
Response: To lowest temperature sensed by any one foot section of its element.
Differential: 5°F (3°C) fixed.
Environment:
  Ambient Temperature Limits,
    Shipping −40 to 150°F (−40 to 66°C).
    Operating Must be 5°F (3°C) above setpoint to a maximum of 150°F (66°C) at case.
    Thermal Sensing Element 300°F (149°C).
  Humidity,
    Enclosure 5 to 95% RH, non-condensing.
    Thermal Sensing Element 0 to 100% RH.
  Locations, NEMA Type 1 indoor only.
Electrical Switch: Snap action SPDT.
  Ratings, See Table 1.
Connections: Coded screw terminals.
Cover: Beige painted steel case with 1/2" conduit opening.
Mounting, In any position on any surface not subject to excessive vibration.
Dimensions:
  Case, 2-1/2" high × 3-1/8" wide × 2-3/16" deep (63 mm × 79 mm × 55 mm).
  Element, 1/8" OD × 20' length (3 mm × 6.1 m).

ACCESSORIES None

ITEM NO. 18
SUBMITTAL PARA. —
PRODUCT PARA. 2.1.7.4

TABLE 1. SPECIFICATIONS

Part Number	Device Type	Voltage Vac	Full Load Amps	Locked Rotor Amps	Pilot Duty (VA)	Non-Inductive Amps
TC-5131	Low temp auto reset	24	—	—	100	16
		120	13.8	82.8	650	16
TC-5141	Low temp manual reset**	208	9.6	57.6	750	9.6
		240	8.3	49.8	750	8.3
		277*	—	—	—	7.2

*277 Vac not CSA approved.
**Reset cannot be accomplished until the sensed temperature is at least 5°F above setpoint.

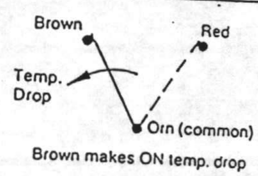


Figure 1. TC-5131 or TC-5141
Switch Action and Terminal Identification

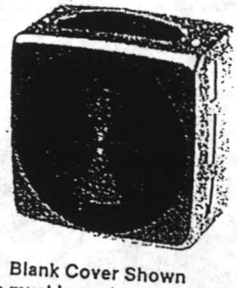
Dual Setpoint/Dead Band Room Thermostat

T35 Series
T36 Series

APPLICATION

The T35 and T36 series dual setpoint/dead band pneumatic room thermostats are designed for the proportional control of pneumatic valves, damper actuators and other final control devices in environmental control systems. These devices are for use when it is desirable to set up a temperature span within which the HVAC system uses no energy for heating or cooling between selected heating and cooling setpoints. The high capacity, two pipe, pilot-operated relay type design provides pneumatic feedback for accuracy and stability over the entire operating range.

These thermostats are available in either direct or reverse acting models. Two bimetals are utilized, one heating and one cooling, to interrupt the dead band (branch) pressure. The heating bimetal modulates the pressure between zero and the dead band pressure, and the cooling bimetal modulates the branch pressure between the dead band pressure and main air pressure. The dead band pressure is adjustable in the field to adapt to specific applications. Two concealed setpoint dials, one heating and one cooling, are used to set the individual heating and cooling setpoints to the desired values. This creates the desired "dead band" which will occur between the two selected setpoints. All calibration functions are accessible from the front of the thermostat.



Blank Cover Shown
Covers must be ordered separately

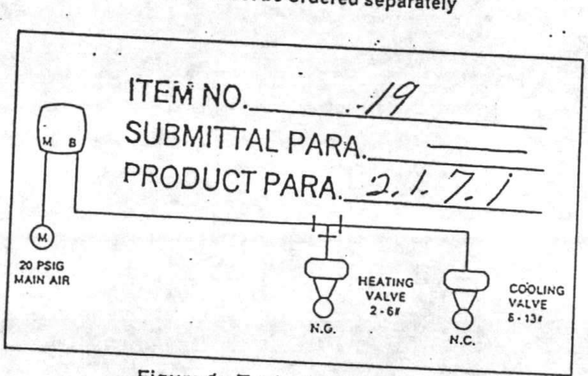


Figure 1. Typical Application

SPECIFICATIONS

Action: Proportional.
T35-301, Direct.
T36-301, Reverse.

Setpoint Range:
Heating, 57 to 75°F (14 to 24°C).
Cooling, 65 to 83°F (18 to 28°C).

Throttling Range: 1.5°/5 psi non-adjustable for each setpoint (approximately).

Construction:
Components, Die cast aluminum, stainless steel and Lexan.
Diaphragms, Fabric-reinforced neoprene.
Air Filter, Internal.

Supply Air Pressure: Clean, dry, oil free air required.
Operating, 20 psig (138 kPa).
Maximum, 30 psig (207 kPa).

Connections: For spring-reinforced 3/16" plastic tubing and required fittings (order separately).

Air Consumption: 0.009 scfm.

Calibration Point:
Dead Band, Factory set at 7 psig (adjustable).
Direct Acting T35-301,
Heating 4 psig @ setpoint.
Cooling 10.5 psig @ setpoint.
Reverse Acting T36-301,
Cooling 4 psig @ setpoint.
Heating 10.5 psig @ setpoint.

Cover Options: See CT-X1, CTR-X1 for cover options (order separately).

Setpoint Adjustments: Individual concealed adjustments for heating and cooling by means of N2-4 calibration tool.

Mounting: Upright position on wall.

Dimensions: 2-1/32" high × 2-1/32" wide × 1-3/8" deep (52 mm × 52 mm × 35 mm).

TABLE 1. COMPETITIVE CROSS REFERENCE

Robertshaw Model No.	Honeywell	Powers
T35	TP970C	TH182DS
T36	TP970D	TH182RDS

Note: Physical and functional difference exists between models. Review model specifications, applications and dimensions before selection of a replacement.

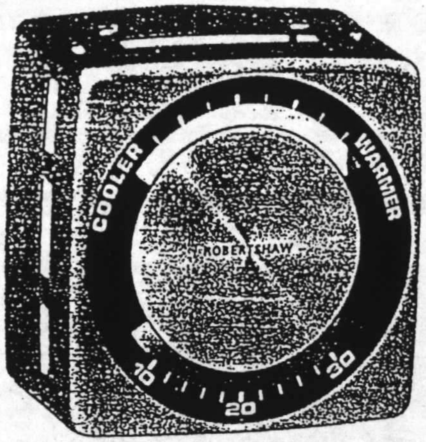
ACCESSORIES

6-371	Mounting ring (use with mounting heads)
10-07	Mounting head, 2 tube, copper
10-15	Aspirating box, 2 pipe
10-53	Metal thermostat guard
10-57	Mortar joint fitting, 2 tube, copper
10-58	Mounting ring (use with N5-52)
10-59	Internal stop kit
10-62	Clear plastic cover thermostat guard
10-63	Insulating backplate, for plastic guards
10-64	Tubing assembly with eyelets and fittings
10-66	Mortar joint fitting, 2 "FR" tubes
10-67	Mounting ring, vinyl adhesive
10-72	Concealed adjustment cover, for metal covers
10-73	Drywall mounting fitting (snap-in)
10-76	Opaque plastic guard
10-77	Adaptor plate
10-78	Insulating backplate
10-81	Concealed adjustment cover, for plastic cover
10-82	Mounting plate for 2 × 4 switch box
MCS-GA	Gauge tap adaptor
N2-4	Calibration tool
N5-49	Adaptor (for use with N5-53)
N5-52	Bracket, drywall mount
N5-53	Bracket, stud mount rough-in
N5-95	Wall thermostat, conversion kit

Thermostat Covers

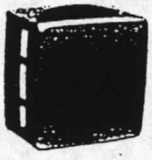
C Series


C1-42



C6X42


C3-42


C2-42

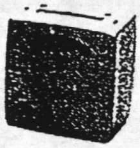

C4-42


C5-42


C6-42


C10-42


C11-42


C13-42


C14-42


C15-42


C1X42


C1X62


C3X42


C3X62


C4X42


C4X62


C6X42


C6X62

ITEM NO. 20

SUBMITTAL PARA. —

PRODUCT PARA. 2.1.7.1

Continued on next page

CALIBRATION & ADJUSTMENT INSTRUCTIONS

DEADBAND ROOM THERMOSTATS

DIRECT AND REVERSE ACTING

T35 (D.A.)
T36 (R.A.)

CALIBRATION

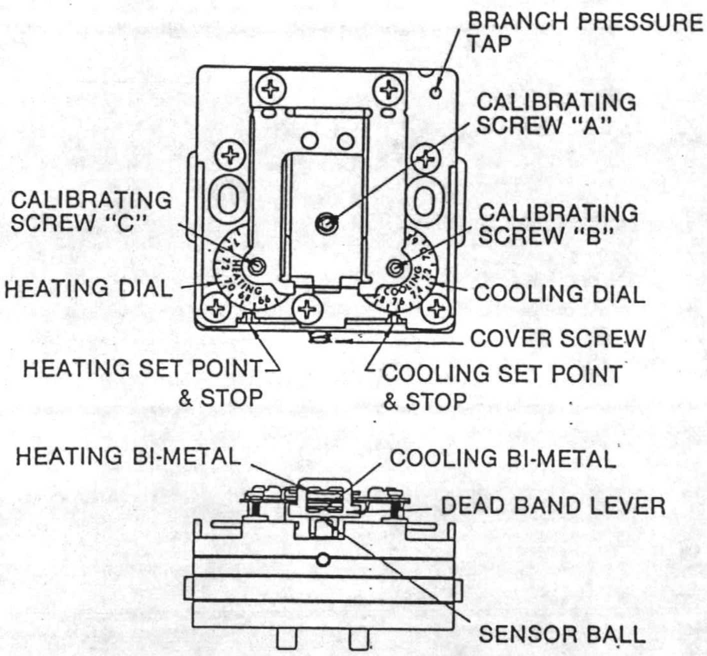


FIGURE 1 — T35 WITH COVER REMOVED

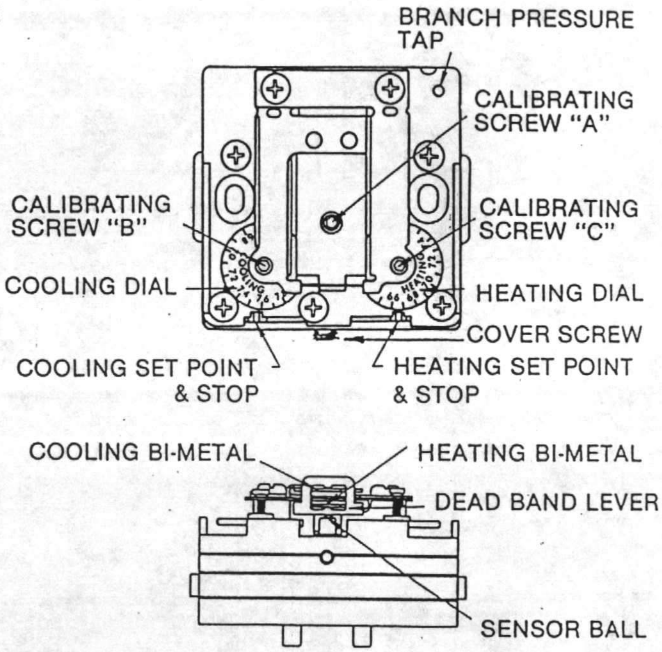


FIGURE 2 — T36 WITH COVER REMOVED

The T35 is factory calibrated to operate a 2-6# normally open heating actuator and an 8-13# normally closed cooling actuator in sequence; therefore, its "intermediate" pressure is factory set at 7 psig. Branch pressure is factory set at 4 psig when the heating dial is positioned at actual ambient temperature, and 10 1/2 psig when the cooling dial is positioned at actual ambient temperature.

The T36 is factory calibrated to operate an 8-13# normally-closed heating actuator and a 2-6# normally open cooling actuator in sequence; therefore, its "intermediate" pressure is factory set at 7 psig. Branch pressure is factory set at 10 1/2 psig when the heating dial is positioned at actual ambient temperature, and 4 psig when the cooling dial is positioned at actual ambient temperature. If it becomes necessary to check calibration or to change calibration to match other heating and cooling spring ranges, the procedure is as follows: **For T35, refer to Figure 1; For T36, refer to Figure 2.**

23A

Insert a branch tap adapter MCS-GA and pressure gauge into the thermostat branch tap hole. Measure the ambient temperature, which **must be between 65° and 75°F.** Using the thermostat wrench (N2-4) turn the heating dial hex screw "C" to set the heating dial at 57°F. Then turn the cooling dial to the 83° setting. This moves both bimetals away from the deadband lever which controls the intermediate or deadband pressure. Turn the deadband pressure adjustment screw "A" so the branch pressure equals the midpoint between the high end of the heating actuator and the low end of the cooling actuator, i.e., with a 2-6# heating actuator and an 8-13# cooling actuator, the pressure should be 7 psig. Next, position the heating dial so that the Branch output pressure equals the mid-range of the heating actuator at the ambient temperature read on the thermometer. If there is a difference between the temperature set point on the heating dial and actual ambient temperature, rotate the heating dial in the appropriate direction to the end stop. Then, "slipping" the screw inside the dial, continue rotating the screw the amount of difference previously observed between the ambient temperature and set point. Then, return the dial so that the desired branch output pressure is observed at ambient.

The cooling set point may now be calibrated in the same manner (Screw "B"). Finally, set both heating and cooling dials to the desired set points and re-install the cover.

ADJUSTMENT

NOTE: Concealed adjustment covers are used with the T35 and T36 thermostats. Using Thermostat Wrench N2-4 (1/16" hex), turn the Cover Screw inward (clockwise) to provide clearance for cover removal.

HEATING AND COOLING SET POINTS

With the cover removed, use Thermostat Wrench N2-4 to rotate the Heating Dial and/or Cooling Dial until the desired heating and cooling set points are aligned with their respective indexes. Replace cover.

Zero Energy Band, Floating, Two-Position Room Thermostats

APPLICATION

For on-off control of heating/cooling systems.

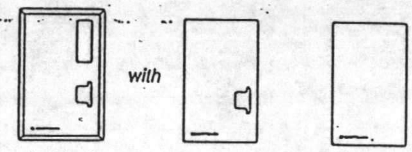
SPECIFICATIONS

Anticipation:
TC-18X-770 Series, Cooling is fixed.
TF-1111-770, Heating and cooling; factory-installed resistors are sized for 0.16 FLA @ 24 Vac maximum.

Fan Switch:
TC-18X-770 Series,
Marking Low-Off*-Med-High.
TC-19X-770 Series,
Marking Off-Lo-Hi*.
Construction Integral two-pole three-position.

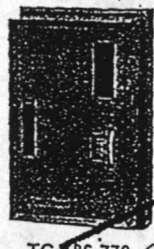
*Off position de-energizes thermostat and fan.

Sensing Element: Bimetal.
Mounting: Flush or 2 × 4 switch box.
Locations: NEMA Type 1 indoor only.



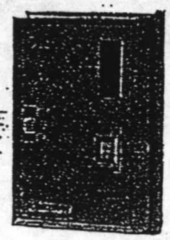
Standard with Insert Insert

TC-114-770

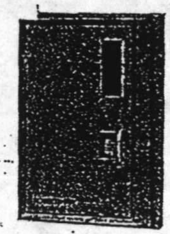


TC-186-770
TC-187-770
TC-188-770

TC-114-770
TC-186-770
TC-187-770
TC-188-770
TC-195-770
TC-199-770
TC-1101-770
TC-1102-770
TC-1103-770
TC-1191-770
TF-1111-770



TC-195-770
TC-199-770



TC-1191-770
TC-110X-770
TF-1111-770

TABLE 1. TC-110X-770, TC-1191-770 & TF-1111-770 INCLUDE

Quantity	Description
1	Blank cover insert
1	Cover insert with setpoint dial cutout
1	5/64" Allen head screw for securing cover to thermsotal base
1	5/64" Allen wrench
2	Dial stop pins to limit setpoint range

†TABLE 2. AGENCY APPROVALS

Configuration	Part Number	UL Listed	CSA Certified
Metal cover	TC-19X-770	Yes	Yes
Plastic cover	TC-114-770	Yes	No
	TC-18X-770	Yes	No
	TC-110X-770	Yes	No
	TC-1191-770	Yes	No
	TF-1111-770	No	No

ACCESSORIES

AT-70 Series	Brushed bronze cover plates
AT-82-770	Digital thermometer cover kit for TC-1191-770, TC-110X-770 & TF-1111-770
AT-101	Lock cover kit
AT-104	Dial stop pins
AT-136	Title plates (day, night, heat, cool)
AT-504	Plaster hole cover kit (small)
AT-505	Surface mounting base
AT-546	Auxiliary mounting plate
AT-602	Selector switch sub-base DP4T
AT-603	Selector switch sub-base one DP4T, one DPDT
AT-1100 Series	Thermostat guards
AT-1103	Wire guard
AT-1104	Cast aluminum guard
AT-1105	Plastic guard
AT-1155	Plastic guard
AT-1165	Plastic guard
PKG-1093	Digital thermometer battery replacement kit for TC-1191-770, TC-110X-700 & TF-1111-700
TOOL-11	Calibration wrench
TOOL-13	Contact burnishing tool

ITEM NO. 21, 22
SUBMITTAL PARA. ——
PRODUCT PARA. ——

Continued on next page

Zero Energy Band, Floating, Two-Position Room Thermostats

TC-114-770, TC-186-770, TC-187-770, TC-188-770, TC-195-770, TC-199-770, TC-1101-770, TC-1102-770, TC-1103-770, TC-1191-770, TF-1111-770

Continued from preceding page

TABLE 2. SPECIFICATIONS

Application	Part Number	Setpoint Dial Range	Differential	Electrical switch See Table 3	Connections	Cover	Dimen. In. (mm) H × W × D
On-off control of unit heaters or motors	TC-114-770	50 to 86°F (10 to 30°C) Dual marked	Heat, 2°F (1.1°C) Cool, 3°F (1.7°C)	SPDT snap action	Color-coded 6" leads	Beige plastic with metal brushed bronze insert	4½ × 2¾ × 1-1/8 (114 × 70 × 29)
Sequenced on-off control of line voltage fan coil or zone valves on heating and cooling systems	TC-186-770 TC-187-770 TC-188-770	55 to 85°F	Heat, 2°F Neutral, 2°F Cool, 2°F	SPDT switch zero energy band (neutral center)	Coded screw terminals and color-coded 6" leads	Beige plastic with metal brushed bronze insert	4⅜ × 2¾ × 1⅝ (111 × 70 × 41)
On-off control of line voltage fan coil or zone valves on heating and cooling systems	TC-195-770	55 to 85°F (13 to 29°C)	1.5°F (0.8°C)	SPDT snap action	Coded screw terminals and color-coded 6" leads	Beige metal with metal brushed bronze insert	4⅜ × 2¾ × 1⅝ (111 × 70 × 41)
	TC-199-770		Heat, 2°F (1.1°C) Neutral, 2°F (1.1°C) Cool, 2°F (1.1°C)	SPDT zero energy band (neutral center)			
Low or line voltage on-off control of fan coils, fans, motor starters, contactors, two-position electric actuators	TC-1101-770	55 to 85°F	2°F	SPDT snap action	Color-coded 6" leads	Beige plastic as standard	4⅜ × 2⅞ × 1⅝ (111 × 73 × 41)
	TC-1102-770	45 to 75°F					
	TC-1103-770	75 to 105°F					
Low or line voltage on-off control of heat/cool systems such as 3 or 4 pipe unitary	TC-1191-770	55 to 85°F	Heat, 2°F (1.1°C) Neutral, 2°F (1.1°C) Cool, 2°F (1.1°C)	SPDT snap action (neutral center)	Color-coded 6" leads	Beige plastic as standard	4⅜ × 2⅞ × 1⅝ (111 × 73 × 41)
Floating control of one MF-1233 series actuator	TF-1111-770	55 to 85°F	4°F	SPDT floating off 0.160 FLA @ 24 Vac	Color-coded 6" leads	Beige plastic as standard	4⅜ × 2⅞ × 1⅝ (111 × 73 × 41)

TABLE 3. ELECTRICAL RATINGS

Part Number	Fan Switch			Thermostat Contacts				
	Volts (AC)	Full Load Amps	Locked Amps	Volts (AC)	Full Load Amps	Locked Rotor Amps	Pilot Duty (VA)	Non-Inductive Amps
TC-114-770	—	—	—	120/240	9.8/8	58.8/48	—	25/25
TC-186-770	24	6	36	24	4.4	26	40	—
TC-187-770	120	6	36	120	4.4	26	125	—
TC-188-770	240	3	18	240	3	18	125	—
TC-195-770	120/240	6/3	36/18	120/240	3/1.5	18/9	125	—
TC-199-770	120/240	6/3	36/18	120/240	1.0/0.5	6/3	40	—
TC-1101-770 TC-1102-770 TC-1103-770	—	—	—	24 120 240	4.4 4.4 2.2	26.4 26.4 13.2	40 210 210	—
TC-1191-770	—	—	—	24/120/240	Heat, 4.4/4.4/2.2 Cool, 3.0/3.0/1.5	Heat, 26.4/26.4/13.2 Cool, 18/18/9	40/210/210	—

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ITEM NO.	SUBMITTAL PARAGRAPH	DESCRIPTION	PAGE NO.
200	1.4.2.A,C, D,E,F,G	CONTROL DIAGRAM	SEE CONTROL DIAGRAM
201	1.4.2,B	SEQUENCE OF OPERATION	1
202	1.4.2,H	VALVE SCHEDYKE	3
		TEST PLAN AND TROUBLE SHOOTING GUIDE	4
		MAINTENANCE REQUIREMENTS	11

ITEM NO. 201
SUBMITTAL PARA. 1.4.2.b
PRODUCT PARA.

SECTION 1.4.2

1.4.2A SEE ATTACHED DRAWINGS

1.4.2B SEQUENCE OF OPERATION

MAKE UP AIR UNITS (MAU1-MAU3)

When any of the carbon monoxide exhaust fans are energized, the make up air fan will be energized, outside air damper will open. Discharge air temperature will be maintained by the supply air temperature controller at 65 degrees F which will modulate the face and bypass dampers open to the coil on a fall in temperature and closed to the coil on a rise in temperature.

If all of the exhaust fans are off, the make up fan will be de-energized and the outside air damper will close.

The make-up unit can also be started by placing the starter switch to the hand position.

A low limit thermostat will stop the unit fan and close outside air damper if the duct temperature falls below 38 degrees F which will require manual reset.

UNIT HEATERS

Space thermostats will cycle unit fans to maintain 65 degrees F.

CARBON MONOXIDE FANS (VE1-VE10)

Exhaust fans will be started and stopped manually by start-stop buttons on the starter.

EXHAUST FANS (E1-E7)

Space thermostats will cycle fans to maintain temperature at 75 degrees F.

EXHAUST FANS TE1 AND TE2

Exhaust fans will start whenever its respective rooftop unit S1 or S2 starts and will stop when rooftop unit stops.

HOT WATER PUMP (P-1)

Pump will run continuously when starter switch is placed in the on position.

FAN POWERED VARIABLE VOLUME UNITS

Day operation - Fan runs continuously
Space thermostat will modulate unit hot water valve closed on a rise in temperature above 68 degrees F. Between 68 and 78 degrees F, the unit damper will maintain a minimum primary air flow. Once space temperature approaches 78 degrees F, the primary air flow will be increased to provide cooling for the space. As the temperature falls below 78 degrees F, the primary air flow will be reduced back to a minimum position.

NIGHT OPERATION

When rooftop unit shuts down, all VAV box fans will be de-energized.

If the building night thermostat senses a temperature fall below its setpoint of 55 degrees F all of the VAV box fans will be brought back on with the unit hot water valves open to heat the building back up above 55 degrees F at which time the VAV box fans will be de-energized.

Rooftop units will remain off at night.

WARM-UP CYCLE OF UNITS S-1 AND S-2

The morning warm-up cycle will be initiated one hour before occupancy time. When started all VAV box fans will be energized with space thermostats controlling unit valves to bring space temperature up to occupancy temperature of 68 degrees F. Once space temperature reaches 68 degrees F, the unit valves will modulate closed. At occupancy time, the rooftop unit fans will be energized along with its controls.

DAY OPERATION OF S-1 AND S-2 UNITS

Supply and return fans will be started and stopped by its time clock.

Static pressure will be controlled by modulating the inlet vanes on the supply and return fans from the units remote controller.

Leaving air temperature will be controlled from a discharge air sensor.

When the discharge air temperature rises above its setpoint of 58 degrees F, the economizer dampers will be modulated open to provide free cooling from the outside air if the enthalpy of the outside air is less than that of the return. If the enthalpy is higher with outside air than with return air the economizer dampers will stay at their minimum position.

On a continued rise in discharge temperature, the mechanical refrigeration will be brought on line and will cycle to maintain discharge temperature.

Robertshaw
CONTROL SYSTEMS DIVISION

ITEM NO. 202
SUBMITTAL PARA. 1.4.2.h
PRODUCT PARA.

JOB NO. 18015
JOB NAME Maint. Tng. Fac.
SHEET 1 of 1

VALVE SCHEDULE

UNIT #	HEATING VALVE						COOLING VALVE			
VAV BOXES	GPM	#/HR	CV	SIZE	VALVE NO.		GPM	CV	SIZE	VALVE NO.
RM 233	1.1		2.2	1/2"	VK-9213-201-4-3					
235	1.1		↓	↓	↓					
237	1.4									
243	.5									
247	.9									
253	1.5									
253	1.5									
255	1.4									
255	1.4									
257	1.6									
257	1.6									
202	.5									
215	.5									
216	.5									
219	1.5									
221	.5									
225	1									
227	1									
229	1.4		↓	↓	↓					

ITEM NO.__________
SUBMITTAL PARA.__________
PRODUCT PARA.__________

TEST PLAN AND TROUBLE SHOOTING GUIDE

UNIT	PROCEDURE	RESULTS	COMMENT
ROOFTOP UNIT S-1	* SEE MANUFACTURERS CHECK OUT PROCEDURES		
STATIC PRESSURE	* SEE MANUFACTURERS CHECK OUT PROCEDURES		
ECONOMIZER OPERATION	* WITH UNIT RUNNING AND CALLING ECONOMIZER DAMPERS FOR FREE COOLING		
	SIMULATE A RISE IN OUTSIDE AIR ENTHALPY BY PLUGING OFF SIGNAL LINE OAH IN THE H100-01 ENTHALPY CONTROLLER	ECONOMIZER DAMPERS WILL GO TO A MINIMUM OUTSIDE AIR POSITION	
	SIMULATE A FALL IN OUTSIDE AIR ENTHALPY BY UN-PLUGING SIGNAL LINE OAH IN THE H100-01 ENTHALPY CONTROLLER	ECONOMIZER DAMPERS WILL OPEN TO THE OUTSIDE AIR CLOSING THE RETURN DAMPER PROPORTIONATELY	
	RECONNECT OUTSIDE AIR ENTHALPY TRANSMITTER LINE TO OAH	UNIT WILL GO BACK TO LOCAL CONTROLLER	
DAY/NIGHT CONTROL	PLACE UNIT TIMECLOCK INTO DAY MODE BY PRESSING TIMECLOCK OVERRIDE BUTTON	UNIT WILL START ENERGIZING ALL OF UNIT CONTROLS *	*NOTE: SEE MAN CHECKOU PROCEDU
	RETURN UNIT TIMECLOCK TO NIGHT MODE.	UNIT WILL BE DE-ENERGIZED ALONG WITH ALL ITS' SELF CONTAINED CONTROLS*	

UNIT	PROCEDURE	RESULTS
VAV BOXES DAY OPERATION	START ROOFTOP UNIT (S-1 OR S-2) THAT IS ASSOCIATED WITH VAV UNIT	FAN IN VAV BOX WILL START
	SIMULATE A RISE IN SPACE TEMPERATURE BY LOWERING THERMOSTAT HEATING SETPOINT FIRST, THEN LOWERING COOLING SETPOINT	HOT WATER VALVE WILL BE CLOSED AND THEN UNIT SHOULD MODULATE OPEN TO PRIMARY AIR. FAN RUNS CONTINUOUSLY
	SIMULATE A FALL IN SPACE TEMPERATURE BY RAISING SPACE THERMOSTAT COOLING SETPOINT ABOVE AMBIENT TEMPERATURE	HOT WATER VALVE WILL REMAIN CLOSED. FAN WILL CONTINUE TO RUN UNIT WILL MODULATE TO A PRESET MINIMUM PRIMARY AIR FLOW
	SIMULATE A CONTINUED FALL IN SPACE TEMPERATURE BY RAISING HEATING SETPOINT ABOVE AMBIENT TEMPERATURE	HOT WATER VALVE WILL MODULATE OPEN. FAN WILL CONTINUE TO RUN. UNIT WILL REMAIN AT A PRESET MINIMUM PRIMARY AIR FLOW
	RESET HEATING & COOLING SETPOINTS TO PROPER TEMPERATURE SETPOINTS 78F COOLING - 68F HEATING	UNIT WILL FALL BACK INTO DESIGN CONDITIONS
	PLACE ROOFTOP UNIT INTO THE UNOCCUPIED MODE	VAV BOX FAN WILL BE DE-ENERGIZED

UNIT	PROCEDURE	RESULTS
VAV BOXES NIGHT OPERATION	PLACE ASSOCIATED ROOFTOP UNIT (S-1 OR S-2) IN THE UN-OCCUPIED MODE	VAV BOX FANS WILL BE DE-ENERGIZED
	SIMULATE A FALL IN SPACE TEMPERATURE AT NIGHT THERMOSTAT BY RAISING SETPOINT ABOVE AMBIENT TEMPERATURE. ALSO SIMULATE TEMPERATURE BELOW VAV BOX THERMOSTAT SETPOINT BY RAISING THE COOLING SETPOINT AND THE HEATING SETPOINT ABOVE AMBIENT TEMPERATURE	VAV BOX FAN WILL BE ENERGIZED. HOT WATER VALVE WILL BE OPEN.
	SIMULATE A RISE IN SPACE TEMPERATURE AT NIGHT THERMOSTAT BY LOWERING THERMOSTAT SETPOINT.	VAV BOX FAN WILL BE DE-ENERGIZED
	RETURN SETPOINTS OF NIGHT THERMOSTAT AND VAV BOX THERMOSTAT TO PROPER SETPOINTS.	VAV BOX WILL FALL BACK TO NORMAL OPERATION

UNIT	PROCEDURES	RESULTS
VAV BOXES MORNING WARM-UP	PLACE ASSOCIATED ROOFTOP UNIT (S-1 OR S-2) IN THE UNOCCUPIED MODE AT TIMECLOCK	ROOFTOP UNIT WILL BE DE-ENERGIZED ALONG WITH VAV BOX FANS
	INITIATE WARM-UP MODE BY PLACING TIMECLOCK WARM-UP OUTPUT TO ON POSITION WITH OVERRIDE BUTTON.	ROOFTOP UNIT WILL REMAIN OFF. VAV BOX FANS WILL BE ENERGIZED WITH HOT WATER VALVES UNDER THE CONTROL OF ITS' RESPECTIVE ROOM THERMOSTATS
	DE-ENERGIZE WARM-UP MODE AT TIMECLOCK	VAV BOX FANS WILL BE DE-ENERGIZED
	RETURN TIMECLOCK TO NORMAL SETPOINTS	UNIT WILL RETURN NORMAL OPERATION

UNIT	PROCEDURE	RESULTS
MAU-1 START-STOP CONTROL	PLACE STARTER SWITCH IN HAND POSITION	MAU-1 UNIT STARTS O.A. DAMPER OPENS
	PLACE START SWITCH IN AUTO POSITION	MAU-1 UNIT STOPS O.A. DAMPER CLOSES
	START ANYONE OR ALL OF CARBON MONOXIDE EXHAUST FANS VE1-VE4	MAU-1 UNIT STARTS O.A. DAMPER OPENS
	STOP ALL OF THE FANS VE1-VE4	MAU-1 UNIT STOPS O.A. DAMPER CLOSES
	RE-START AN EXHAUST FAN VE1-VE4	MAU-1 STARTS O.A. DAMPER OPENS
MAU-1 TEMP. CONTROL	RAISE SETPOINT OF CONTROLLER C-1 ABOVE DUCT TEMPERATURE SIMULATING A FALL IN TEMPERATURE	MAU-1 FACE DAMPER MODULATES OPEN TO THE HOT WATER COIL OPENING THE BYPASS DAMPER
	LOWER SETPOINT OF CONTROLLER C-1 BELOW DUCT TEMPERATURE SIMULATING A RISE IN TEMP.	MAU-1 FACE DAMPER MODULATES CLOSED TO THE COIL OPENING THE BYPASS DAMPER
	RETURN SETPOINT TO 65F	MAU-1 GOES BACK TO MAINTAIN DESIGN CONDITIONS
MAU-1 LOW LIMIT PROTECTION	WITH UNIT RUNNING SIMULATE A FALL IN TEMPERATURE AT LOW LIMIT	UNIT WILL BE DE-ENERGIZED AND O.A. DAMPER WILL CLOSE
	MANUALLY RESET LOW LIMIT	UNIT WILL RE-START O.A. DAMPER WILL OPEN

UNIT	PROCEDURE	RESULTS
UNIT HEATERS	RAISE SETPOINT OF SPACE THERMOSTAT ABOVE ROOM TEMPERATURE	UNIT FAN WILL BE ENERGIZED
	LOWER SETPOINT OF SPACE THERMOSTAT BELOW ROOM TEMPERATURE. RETURN SETPOINT TO 65F	UNIT FAN WILL BE DE-ENERGIZED
EXHAUST FANS E-5 & E-6	LOWER SETPOINT OF SPACE THERMOSTAT BELOW ROOM TEMPERATURE.	FAN WILL BE ENERGIZED
	RAISE SETPOINT OF SPACE THERMOSTAT ABOVE ROOM TEMPERATURE. RETURN SETPOINT TO 75F	FAN WILL BE DE-ENERGIZED
EXHAUST FANS E1-E4 & E7	PLACE STARTER SWITCH TO HAND POSITION	FAN WILL BE DE-ENERGIZED
	PLACE STARTER SWITCH TO AUTO POSITION	FAN WILL BE DE-ENERGIZED
	LOWER SETPOINT OF SPACE THERMOSTAT BELOW ROOM TEMPERATURE	FAN WILL BE STARTED
	RAISE SETPOINT OF THERMOSTAT ABOVE ROOM TEMPERATURE. RETURN SETPOINT TO 75F.	FAN WILL BE STOPPED

UNIT	PROCEDURE	RESULTS
EXHAUST_FAN TE1_&_TE2	START ROOFTOP UNIT S-1 FOR TE1 OR S-2 FOR TE2	EXHAUST FAN WILL BE ENERGIZED
	STOP ROOFTOP UNIT CORRESPONDING TO EXHAUST FAN	EXHAUST FAN WILL BE DE-ENERGIZED
	PLACE UNITS BACK UNDER LOCAL CONTROL	

ROBERTSHAW MAINTENANCE REQUIREMENTS

EQUIPMENT	TYPICAL SERVICE REQUIRED	UNIT MAN HRS		YEARLY MAN HRS
THERMOSTAT & TEMPERATURE CONTROLLERS	CHECK CALIBRATION AND THROTTLING RANGE.	3HRS	TWICE YEARLY	6HRS
EP & PE SWITCHES	CLEAN AND CHECK FOR PROPER	6HRS	TWICE YEARLY	12HRS
PRESSURE CONTROLLERS	CHECK CALIBRATION AND THROTTLING RANGE, EXAMINE PRESSURE CONTROL PIPING FOR LEAKS.	6HRS	TWICE YEARLY	12HRS
HUMIDISTATS	CHECK CALIBRATION AND THROTTLING RANGE	4HRS	TWICE YEARLY	8HRS
DAMPERS	LUBRICATE BEARINGS. CHECK ALL LINKAGE FOR TIGHTNESS AND DAMPER FOR PROPER CLOSE-OFF.	8HRS	TWICE YEARLY	16HRS
ACTUATORS	INSPECT STROKE, POSITIVE POSITIONER RELAY AND ACTUATOR MECHANISM FOR ACCURACY.	8HRS	TWICE YEARLY	16HRS
VALVES	LUBRICATE STEM. ADJUST PACKING AND REPLACE WHERE NECESSARY. CHECK ACTUATOR FOR STROKE.	38HRS	TWICE YEARLY	76HRS
RELAYS	CHECK FOR SWITCHOVER AND OPERATION.	1HR	ONCE A YEAR	1HR
PNEUMATIC SWITCHES	CHECK FOR OPERATION AND	1HR	ONCE A YEAR	1HR

IN ALL CASES, REPLACE COVERS ON CONTROLS AND DEVICES FOLLOWING EACH INSPECTION.

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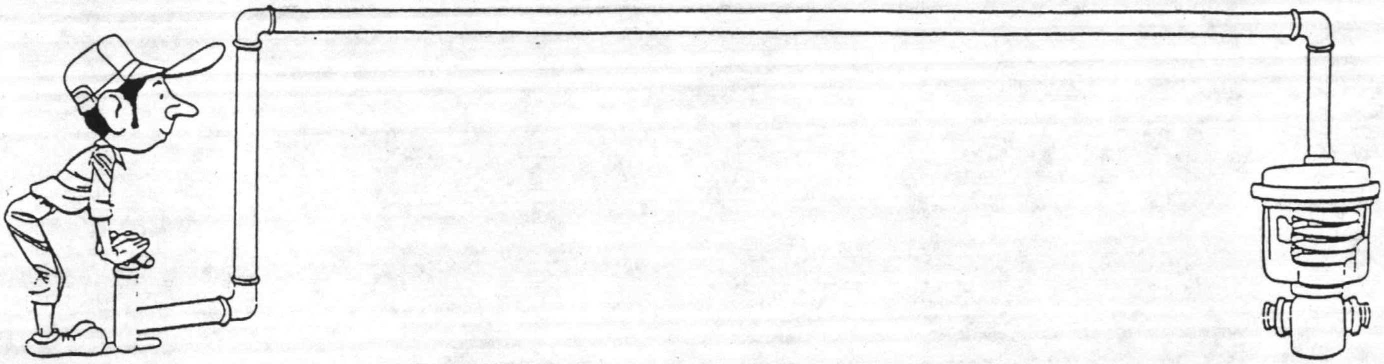


PNEUMATIC CONTROLS SIMPLIFIED

A

TRAINING PROGRAM

BY

PNEUMATIC CONTROLS SIMPLIFIED
Spring Valley, Ca.

RECOMMENDED PROCEDURE

FOR

STUDY

You will notice under Preface the subjects covered and that there are Tape references with each subject. This is an aid in coordinating the text and recorded tapes together.

FIRST It is recommended that you read through the manual starting with "AIR SUPPLY" and stop at the end of this section. It may take more than one reading to grasp the printed information. Do not take the written examination yet.

SECOND Put Tape #1 in the recorder and set the tape counter to zero. Start the tape and play it through to the end of Section #1-A. Of course you can stop the tape and re-wind and play over any part you may be a little hazy on. Also if you want to make a note of exactly where on the tape a specific display or demonstration is shown you can write down the counter reading of that specific location for future reference. Example: Tape #1-A counter #263 - Automatic Drain Traps.

THIRD After you feel that you understand the entire section, take the written examination in the manual at the end of that section.

If you follow this procedure with each section you will gain the most from the program.

#1 AIR SUPPLY - In this section will be discussed Air

TAPE #1-A

Compressors, Driers, Moisture Traps, Pressure Reducing Stations, Filters, Relief Valves and associated equipment you probably have in your own "PNEUMATIC CONTROL SYSTEM".

#2 MASTER AND SUB-MASTER THERMOSTATS - Primary controls

TAPE #1-B

will be the main portion of this section; controls such as the ones used in outside air (OSA) to operate or re-set other controls. Pressure Electric (P.E.) switches, Electric Pressure (E.P.) switches or Valves.

How to set up, calibrate and adjust these controls for proper operation will be included, also actual drawings of their place in a contol system.

#3 CAPILLARY TUBES AND SENSORS - These will be covered in

TAPE #2-A

enough detail so that you can understand their function and purpose.

Although we do not favor, sanction or recommend one make or model of control over another, you will notice that we have included three popular control manufacturers equipment in the demonstrations and sketches. Others may be included also.

#4...DAMPER OPERATORS - As we progress on through the course you

TAPE #2-B

will see how these are used. The types of damper motors or as some say "Damper Operators" will be demonstrated; explaining the spring ranges, strokes and linkage. We will break down much of the equipment to show the construction and how to repair it. You will be shown the various places these operators are used and throughout the course you will be shown how to check each piece of equipment to determine if it is working O.K. and how to repair it if not working.

#5...VALVES...Covered in section 5 will be Line Valves, By-pass Valves,

TAPE #3-A

Diverting Valves, sequence of operation and how to check and change diaphrams. We will cover re-packing, spring ranges, travel adjustment, rebuilding and the operation of valves in the system.

#6...RELAYS - It has been our experience that many mechanics have been

TAPE #3-B

confused by the various relays used in Pneumatic Control Systems. This segment of the program will include Snap acting, Selector, High/Low, Averaging and Pilot Positioning, and reversing relays. How they are incorporated into the system will also be shown.

#7...CALIBRATION - When you see a service bill, have you ever wondered just what is meant by Calibration? Now you are not only going to understand what is meant by the term but you will be shown how to calibrate Master, Sub-Master, Single Input, Double Input, Remote Control Point or (C.P.A.) type of controllers. Also Room Thermostats will be in this demonstration and discussion.

TAPE #4-A

You will be guided step-by-step how to do it and check your adjustments. There are so many short-cuts and easy steps to do it successfully that you will be amazed how quick and easy it is.

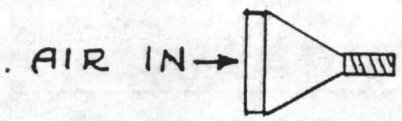
#8...SERVICE PROCEDURES - Now that you have gained a good knowledge of the 7 previous sections we will discuss some practical service procedures. We will cover points that will aid in maintaining a control system that has been put in operation and the preventive maintenance that will keep it functioning well.

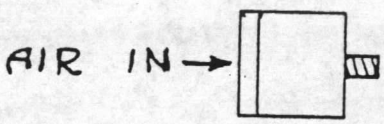
TAPE #4-B

Hints on what to look for on a routine inspection and check sheets for reference month to month. How to read a control drawing or diagram will be taught in a truly simple explanation.

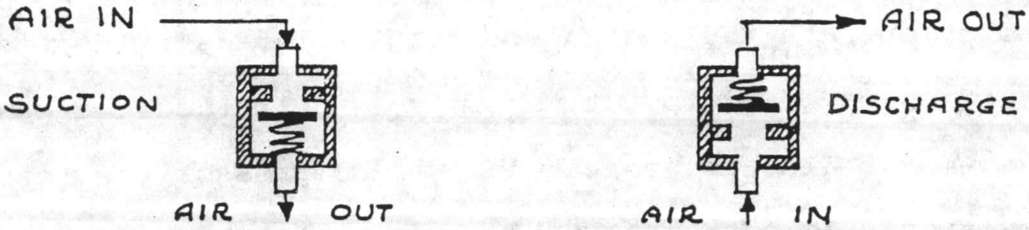
In considering "Air Supply" lets start at the air intake of the air compressor and follow it through to the point where it can be used to operate the controls. The air intake filter is a very important piece of equipment not only to help insure clean air to the system but also to protect the air compressor from excessive wear by filtering out abrasive dust particles.

There are many types of air filters, or air cleaners, used to help clean the incoming air to the air compressor. Among the most popular ones are the DRY, disposable type that is discarded after a certain number of hours of operation, the FELT DISC type that can be washed with a high detergent liquid soap. The larger air compressors may have filters that are cleaned with solvent and re-oiled. These filters may be shown on the control drawing this way:

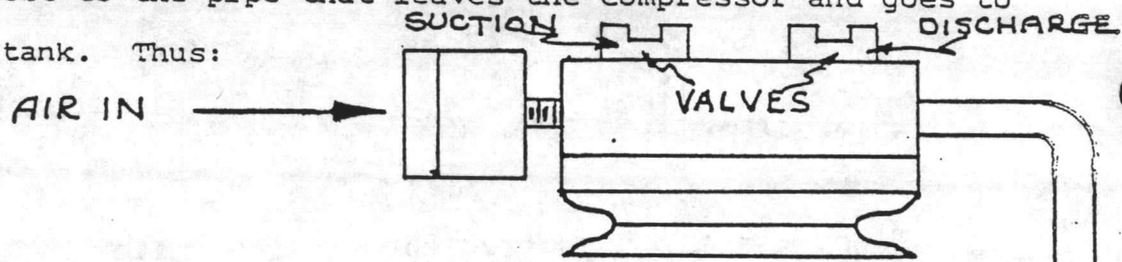




After the air is sucked through the filter by the air compressor it enters the head of the air compressor through the suction or intake valve. When the piston of the air compressor reaches the bottom of its stroke the spring closes the suction valve and as the piston starts up on the up stroke the pressure created by the piston aids in closing the suction valve. This pressure in the cylinder now overcomes the spring pressure of the discharge valve and it opens to let the compressed air out of the compressor. Basically these are check valves that allows air to pass in one direction only and stops, or checks, it from passing in the other direction. Thus:

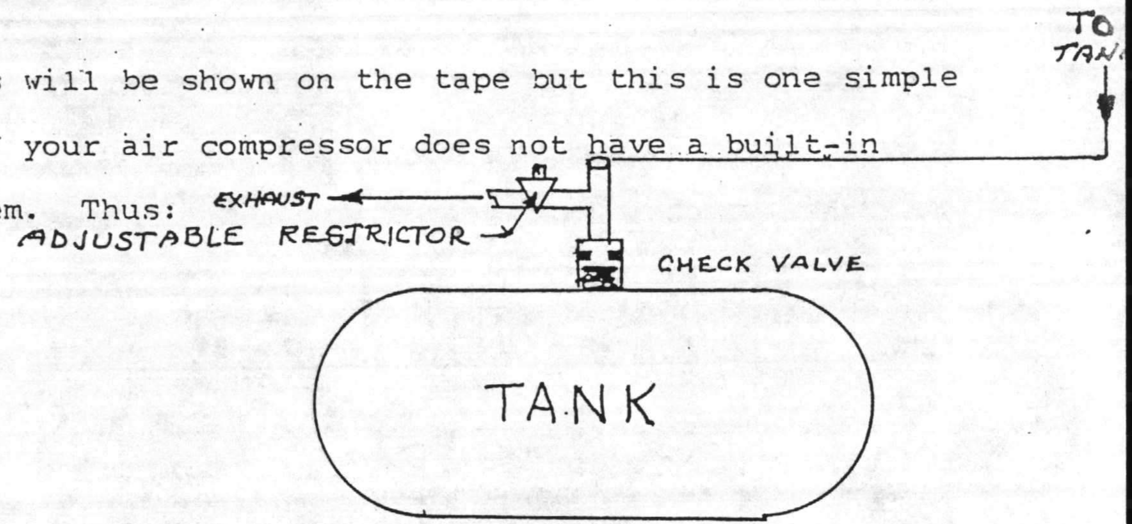


You will notice the principal of pneumatics that we mentioned before of air pressure overcoming spring pressure in the check valves in both the suction and discharge valves of the air compressor. As you observe the two valves in the head of the compressor, suction and discharge, it is easy to identify which is which by their position on the compressor head. The suction valve is usually the one nearest to the air intake filter and the discharge valve the one nearest to the pipe that leaves the compressor and goes to the storage tank. Thus:



Many compressors, especially the larger ones, have a check valve in the pipe that leaves the compressor head and goes to the storage tank. This check valve serves two purposes. 1...To prevent the air from the tank from backing up, after the compressor has stopped running, and leaking out thru the discharge valves if they do not seat tightly. And 2...It allows the pressure in the pipe above the check valve to be "Bled" off so that the air compressor can start un-loaded. Unloaded means that the compressor does not have to pump against a high pressure in the tank. To unload or bleed off this high pressure makes it easier for the electric motor to start the air compressor, saving electricity, strain on the motor and belt and pulley wear.

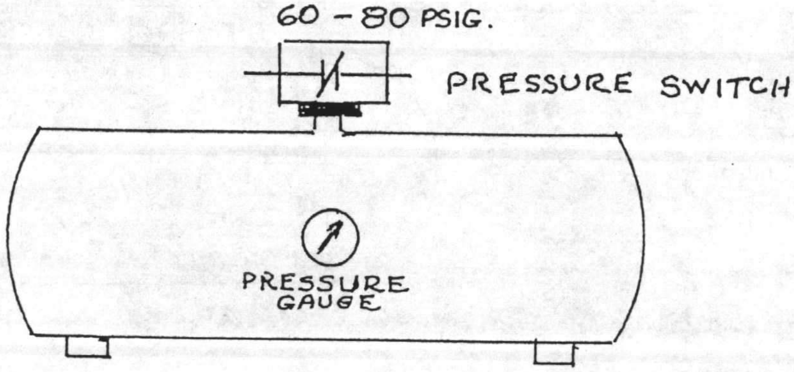
Unloaders will be shown on the tape but this is one simple way to do it if your air compressor does not have a built-in unloading system. Thus:



If using an adjustable restrictor to bleed down the discharge line, the restrictor should be adjusted to bleed all the air off during the "Off" cycle of the compressor.

Now that we have pumped pressure into the storage tank it is necessary to stop the compressor from pumping more pressure into the tank. Usually the way this is accomplished is to stop the drive motor by means of a pressure switch that is connected to the tank. This pressure switch opens its contacts when the pressure in the tank reaches the "cut-out" setting of the pressure switch. This turns off the drive motor to the compressor so no more air is pumped into the tank. As the pressure in the tank drops, due to the system using air, the pressure switch cuts-in or closes its contacts starting the compressor motor again.

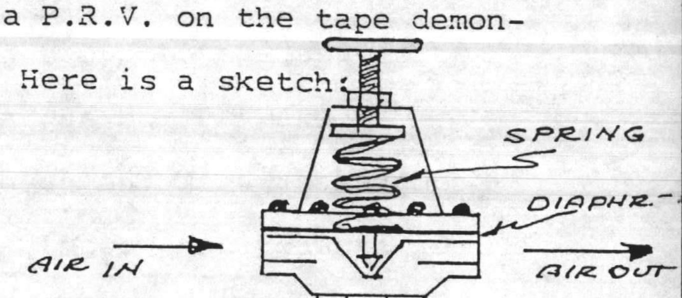
Lets say you adjust the pressure switch to open or stop the compressor when the pressure in the tank reaches 80 PSIG (Pounds per square inch gauge). The gauge on the tank or the high pressure side will read 80. This gauge will be either on the tank or on the line leaving the tank and before the line enters the Pressure Reducing Valve (P.R.V.). Now as the pressure drops to say 60 PSIG the compressor starts. The limits of the settings (60-80PSIG) is called the Range of the pressure switch and the difference of 60 to 80 or 20 lbs. pressure is called the "differential" setting of the switch. Thus:



What we now have is a whole tank full of air somewhere between the pressure of 60-80 psi. This air leaves the tank through the pipe that goes to the Pressure Reducing Valve (P.R.V.) where the pressure is reduced from 60-80psi to 15-25psi, according to the setting of the P.R.V.

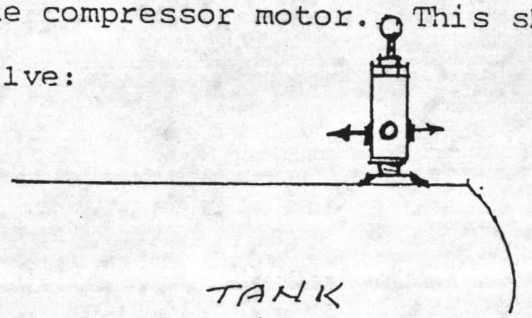
Most control systems use air between this range of 15 to 25 psi. For our demonstrations we are going to use 20 psi as it falls in the range of most pneumatic controls.

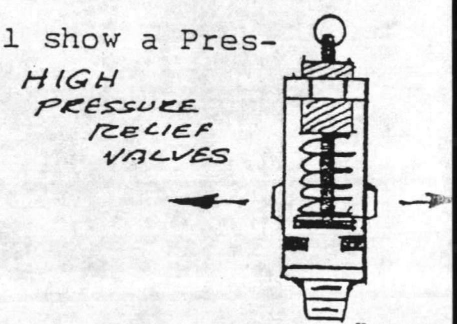
Again this P.R.V. employs the principle of air pressure opposing spring pressure to hold a constant adjustment of 60-80psi in to 20 psi out. We will break down a P.R.V. on the tape demonstration to show how it does its job. Here is a sketch:



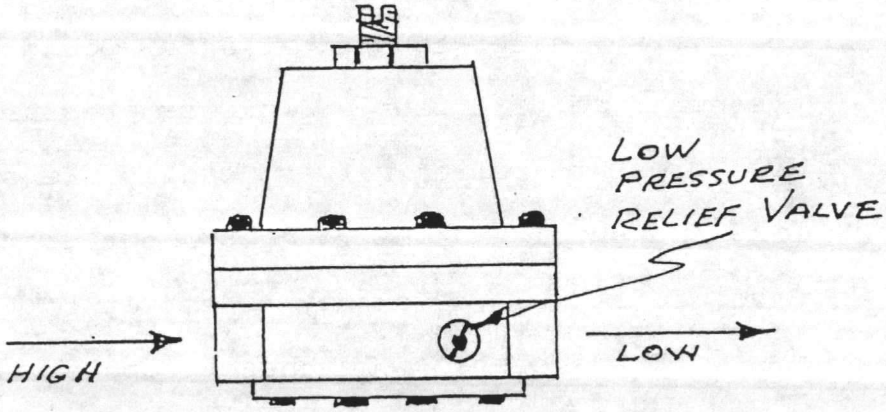
Two very important safety devices are used in "Air Supply" systems and they are called PRESSURE RELIEF VALVES; not to be confused with P.R.V. valves. These pressure relief valves do nothing unless a dangerous condition exists. For example: if the pressure switch should not stop the compressor due to the contacts sticking together or the control becoming defective the compressor would continue to run until something blew up. The pressure relief valve is set to open at a few pounds above normal operating pressure and will blow off excess pressure into the atmosphere. High pressure relief valves usually are sealed with a factory setting and should not be changed under normal conditions. High Pressure relief valves may be set up to 125psi.

If the pressure reaches the point where the high pressure relief valve opens a loud hiss of air will be heard and the compressor will not turn off but continue to run. To correct this problem it is necessary to turn off the switch to the compressor motor and check the contacts on the pressure switch or contactor that starts the compressor motor. This sketch will show a Pressure Relief Valve:





On the low pressure side of the system or after the air is reduced and ready to go out to the control system, you will find another Pressure Relief Valve. This one is set very close to the "Main or Supply" air pressure to protect the control diaphrams from blowing out or rupturing. This Relief Valve is built the same as the high pressure relief valve and the only difference in operation is the spring used. For example, in the high pressure relief valve the opening pressure may be from, say, 90 to 125 lbs.; the low pressure relief valve may open from, say, 22 to 30 lbs. Sometimes these relief valves are found built into the P.R.V. The sketches will show what we mean. Thus:

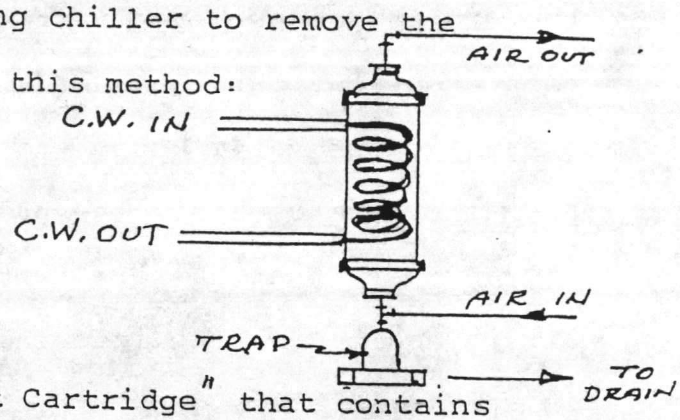


The greatest enemies of Pneumatic Controls are moisture and oil in the main or supply lines. In order to prevent moisture and oil from getting into the Main air lines Air Driers, Oil Filters and traps are used in the system before the air enters the Pressure Reducing Valve, or reducing station. There have been many devices and methods used to dry and clean the air and some will be shown on the tape. First, it is good to stop as much of this contamination of the air with moisture and oil as we can at the compressor location. To accomplish this Automatic Drain Traps and oil separators have been used.

When building or "Plant" air is used to operate pneumatic controls it is usually necessary to add a "Blow Down Filter" before the air enters the P.R.V.

Some moisture separators use the condensation feature to separate the moisture from the air. You no doubt have seen a cold water pipe "sweat" and drip water from the outside of it.

This same principle is often used in a pneumatic control system to separate the moisture from the air. One method is to use the chilled water from the air conditioning chiller to remove the moisture. The following sketch shows this method:



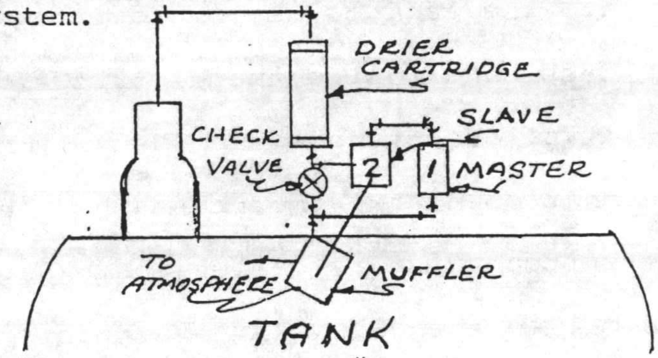
Another device is the "Dessicant Cartridge" that contains a moisture absorbing material that stops and holds the moisture. The air is pumped from the air compressor through the cartridge and either into the tank or is pumped through the cartridge, to dry out the dessicant inside the cartridge, out into the atmosphere. This type of drying system usually has a switch valve and a valve that opens to atmosphere when the switch valve tells it to. The switch valve is called the "Master" and the valve it switches is called the "Slave" valve. This type of drying system can only be used effectively in an air system where the air compressor runs continuously.

In the sketch you will notice that the "Master" valve #1, is set to open at 80psi. When this valve opens, it switches the "Slave" valve #2 to direct the air out to atmosphere through the "Muffler".

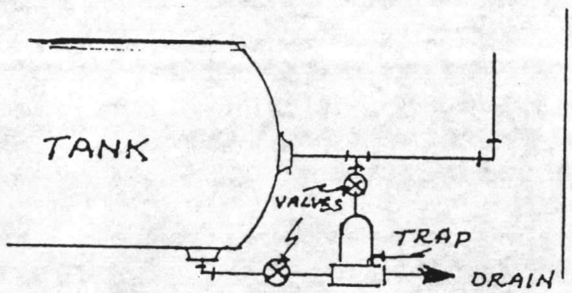
To follow this system through a cycle we find, as the air compressor is started, the "Master" #1 holds the "Slave" valve closed and the air is pumped from the compressor through the drier cartridge into the storage tank. The cartridge is now absorbing moisture from the air entering the tank and holding the moisture in the cartridge. When the "Switching" pressure has been reached, say 80 psi, the "Master" #1 switches the "Slave" #2 and starts the drying process by diverting the hot air discharge from the compressor out through the drier and into atmosphere.

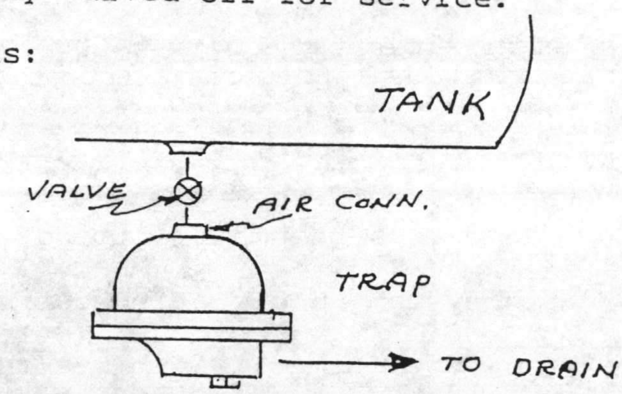
A check valve keeps the air in the tank from backing up and as the system uses air the pressure in the tank is reduced to, say, 60 psi, the "Master" switches the "Slave" to close and the air is again diverted into the tank. This method has been used in smaller systems very effectively if the drier cartridge is changed approximately every two years.

The sketch will show the various components and the operation of a dessicant drying system.



Quite a number of "Automatic Drain Traps" have been manufactured to trap and expel moisture from air compressor tanks and air driers. The most of them use a needle or valve and float for operation. It is a simple but effective process and we will break down some of these on the tape to show the function and service required. Some of the ways these are tied into the system are shown in the following sketches. It is necessary to follow the manufacturers' recommendation very closely when installing these traps as a change in the piping pattern can cause the trap not to work at all. Some traps can be used for both steam and water and should always be piped for the water circuit when being used for water or moisture separation in Pneumatic Systems. Also these traps have to be serviced periodically so should be properly valved off for service. You will note this in the sketch. Thus:





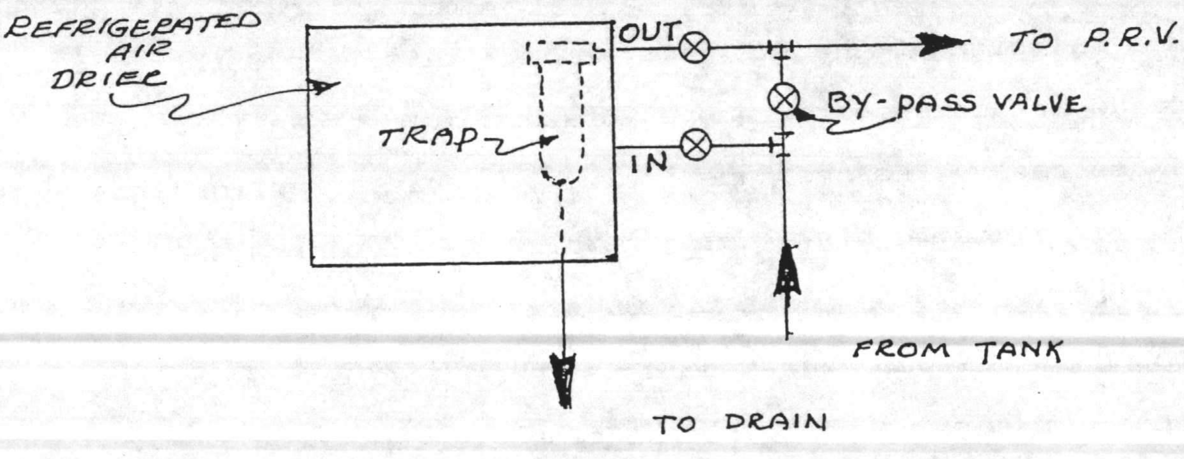
Next we will consider the "Refrigerated Air Drier". This device is connected in series, or in the line from the storage tank to the in side of the P.R.V. station. This is probably the most effective method used to remove moisture from the air lines that is in use today. As the name implies, it has a refrigeration system built in that cools a coil in which the air from the air compressor tank comes in contact. On some models the unit operates continuously and on other models the unit "cycles" to maintain a cold coil or surface that the air comes in contact with.

The chilled water system, using chilled water from the chiller, has the same principle; however, if the chiller is turned off for the season or turned off from outside air temperature going low enough that chilled water is not necessary, the effectiveness of the chilled water system is lost.

In the refrigerated drier, as the entering air comes in contact with the cold surface of the cooling coil or tank, the moisture in the air forms drops of condensation and drips off the cold surface and falls to the bottom of the tank that contains the cooling coil. This is now water and falls into the "Drain Trap" that is located either on the bottom of the cooling tank or teed into the leaving air line from the drier. As this trap starts to fill with water the float lifts and squirts the water down the drain and out.

It is always a good idea to "valve Off" any device that is added to a pneumatic piping system. By doing this you can keep the system in operation during service of these devices, thus saving "down time". At times the drain trap may have to be cleaned or repairs made to the refrigeration unit.

This is the way a refrigerated drier should be hooked up:

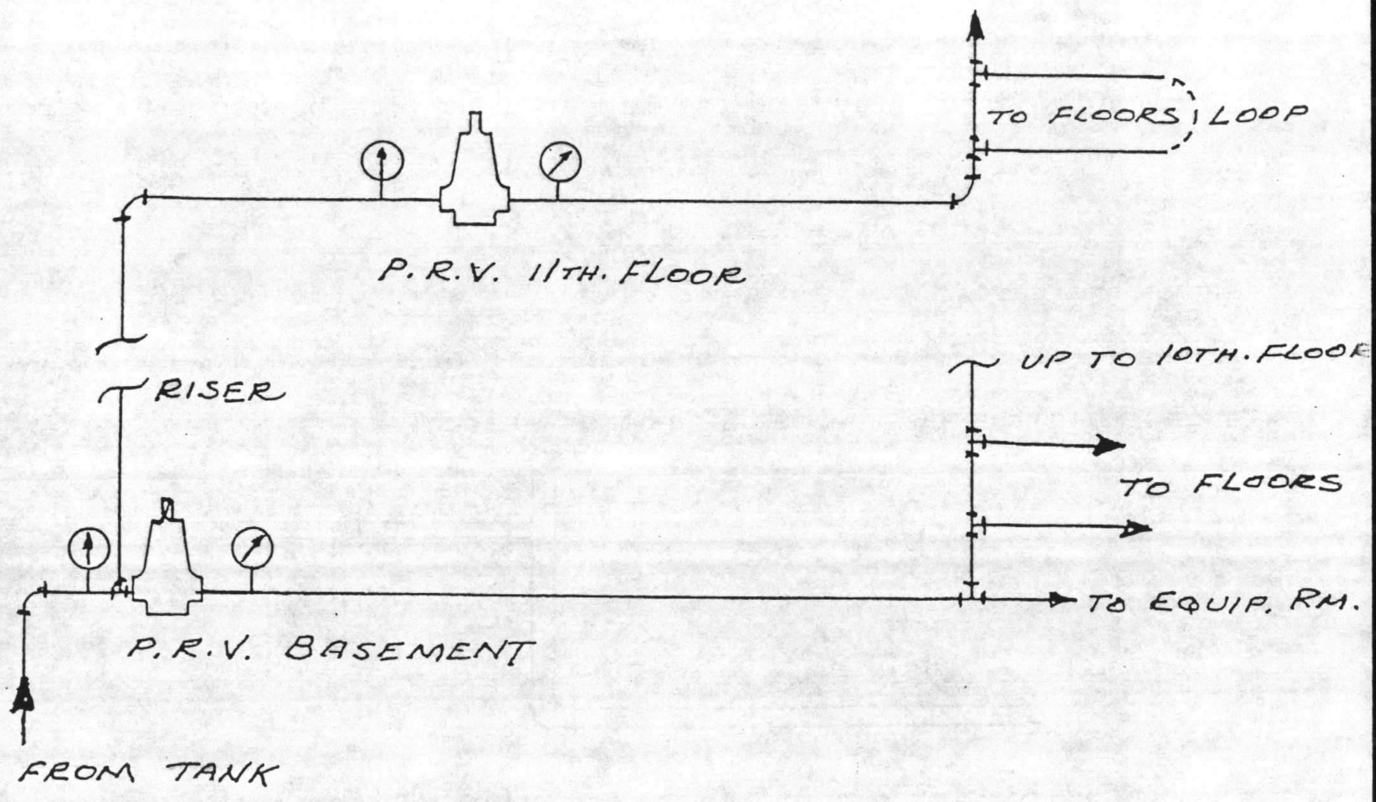


We now have clean, dry air that has passed through the P.R.V. and is ready to be used by the controls. This is now called Ⓜ main air or Ⓢ supply air at 20psi.

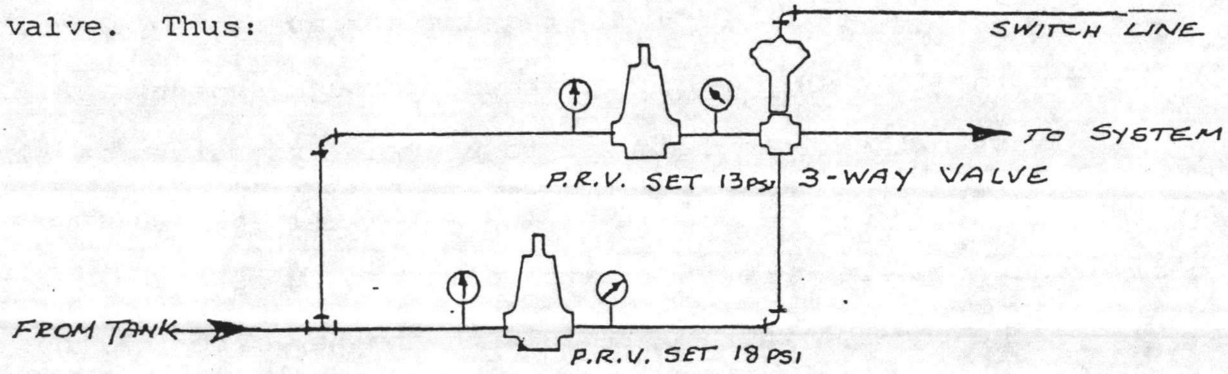
From here it goes to the "Primary" controls, usually mounted on or in control panels in the equipment rooms. It also goes out through the building to feed Ⓜ air to the room thermostats throughout the building.

If the building has many floors and only one source of air supply, it may be necessary to take high pressure to the second half of the building and put it through a second P.R.V. or reducing station. In the sketch you will notice that we are using a 22-story building and feeding (M) air from the bottom up to the 10th floor. We take off high pressure air up to the 11th floor to feed the 11th thru the 22nd floors through another P.R.V.

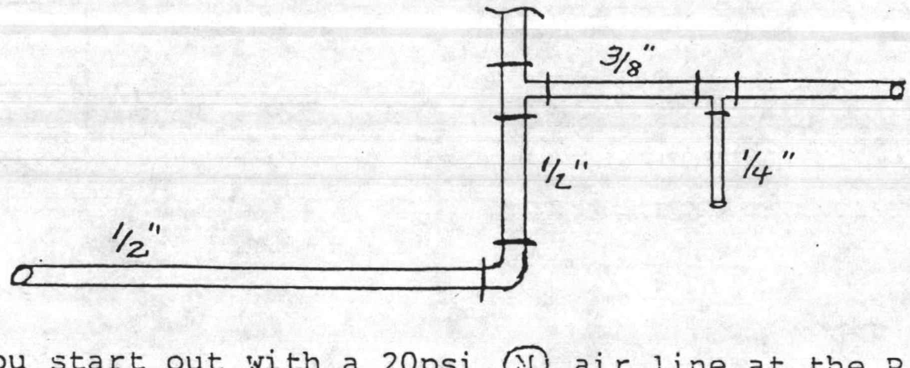
This method is often used to prevent excessive pressure drop in (M) air lines. If you find a low (M) air line on one floor and you are sure there are no leaks, it is often possible to "Loop" the ends of the (M) lines with another floor, either above or below. Sketch shows how:



Some buildings use a "Dual" pressure (M) air system to set-back the room thermostats or for a day/night change-over. A heat/cool situation is also possible by reversing the action of the room thermostats by means of a dual (M) air supply. A very simple way to accomplish this switch-over is to use 2 P.R.V.s and a 3-way valve. Thus:



You can always identify the (M) air line through the building because it will usually be larger than (Br) branch lines from room (T) stats. The (M) lines will usually be 1/2" or 3/8" and the (T) stat. lines will usually be 1/4" or 5/32". This is not always the case, but if you find where the (M) "tees" off from the "riser" or line that goes between floors of a building, it will be larger than the (Br) lines. Another sketch:



If you start out with a 20psi (M) air line at the P.R.V. and find that you only have 12 or 14 psi at the end of the line, there is either a leak along the lines or too many devices pulling the pressure down. First check for leaks at control panel locations and then, if not found, it may be necessary to check above ceilings and riser spaces. Odorizing agents such as oil of wintergreen or spray bombs in the air intake of the air compressor to locate leaks; however, it is best to use these only when the building is not occupied because they can cause panic. Soap bubbles are best to use.

Oftentimes a low Ⓜ can be lived with by adjusting the P.R.V. to put out more pressure. Use caution here that you do not go above the relief valve setting on the Ⓜ air side.

It is time now to see the taped demonstrations and displays on TAPE #1-A. If you do this, it will help greatly when you take the following written review.

WRITTEN REVIEW

Air Supply Section on Tape #1-A

Note: Please do not take this written review until _after_ you have viewed tape #1-A.

1. What 2 purposes does the air intake filter serve?

_______________ and _______________

2. Explain the principle of Pneumatics.

____

3. How would you identify the Suction, or intake valve from the Discharge valve on the air compressor?

____

4. What two purposes does the check valve in the discharge line from the compressor to the storage tank serve?

_______________ and _______________

5. To Unload a compressor means what and why is this necessary?

____

____

6. How do you stop a compressor from pumping more air than is needed?

____

7. When a pressure switch is adjusted to maintain a 60 to 80 psi in the storage tank, what is the range and what is the differential of the switch?

Range_______________psi Differential_______________psi

8. What do the letters P.R.V. stand for?

_______________ _______________ _______________

9. There are two Pressure Relief Valves in air supply systems; where are they located?

_______________ and _______________

10. What are the greatest enemies of penumatic control systems?

_______________ and _______________

11. When using building or "Plant" air for pneumatic controls, what is it necessary to add before the air enters the P.R.V.?

____

12. Dessicant drying systems would be used on which system?

A. A continuously running _______________ or

B. Compressor that cycles _______________

13. An "Automatic Drain Trap" is used to do what?

____

14. What is the most effective way to separate moisture from control air?

____

15. Why would a refrigerated drier be better than a chilled water drier?

____

16. When does the air become (M) main air or (S) supply air - after it leaves what device?

_______________ _______________ _______________

17. Why is it good to "Valve Off" any added device to a penumatic piping system?

____

18. In a high-rise building, say, 22 stories, how would you maintain a 20psi (M) on all floors?

____

LETS GO ON TO THE NEXT SECTION #1-B.

TOOLS

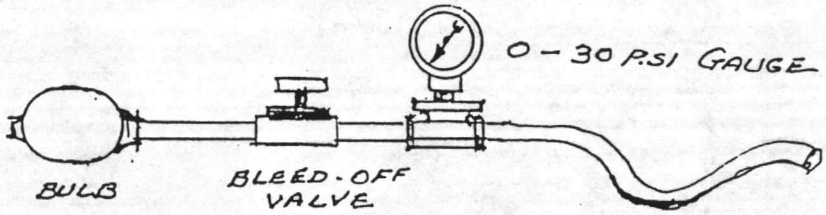
At this point in our program, it is time to consider the tools you will need to perform the service and repair jobs on a pneumatic control system. As you will notice, outside of a few special tools, most of the tools required are ones that you use every day to repair anything. It has been found that to handle "Spot" problems on control systems it is very good to use a fishing tackle box or similar tool box with small compartments.

As time goes by you will accumulate fittings and small parts you need handy for your system. You will see on the tape a tool box that has been used for the past several years and the advantages of it are:

1. Small size, convenient to carry.
2. Compartments for fittings, screws, etc.
3. Everything in one place.
4. Only the tools you need most.
5. Ready for emergency calls.

The one disadvantage is that every tool you need seems to be either in the back or the bottom of the box, and you have to remove other tools to get to it.

One of the most important tools you will need is a "SQUEEZE BULB". You will see this used quite frequently in the taped demonstrations and is really a must for pneumatic control servicing. The bulb and valve are available from either your control company or the nearest medical supply house where they sell equipment to take blood pressure. The following sketch may help you to make up this tool. Make sure to get the bleed-off valve along with the squeeze bulb.



The material needed to make up this tool is as follows:

1. One squeeze bulb with valve.

2. One small bottom mount gauge. (2" gauge is more accurate than 1-1/2")

3. One 1/8" pipe tee and about 2 feet of 1/4" tubing.

4. Assorted fittings to connect squeeze bulb to the tee and tee to the line. Clamps may be necessary to insure a tight connection.

After this tool is made up, it should be tested by plugging the end of the flexible tube and pumping at least 10psi pressure on the gauge. If it does not hold this pressure, it will be necessary to soap the joints, find the leak and repair it. It has to be tight.

Other tools:

1. Small test gauge with adapter for your type thermostats.

2. Special wrenches to open and adjust your room thermostats.

3. Digital thermometer. (The M-99 electro:therm available from Heath-Kit stores is excellent. It sells for about $50.00 and is a real time-saver). A good pocket thermometer that can be recalibrated works fine also.

4. Good flashlight.

5. Soap test bottle. A cleaned-out nail polish bottle works well and contains the small brush to use in tight places and joints.

6. 8" channel lock pliers.
7. 6" automotive pliers.
8. 6" crescent wrench.
9. 6" diagonal pliers.
10. 6" Lineman s side-cutting pliers.
11. 6" Needle-nose pliers.
12. 8" and 6 flat-blade screwdriver.
13. 6" Phillips screwdriver.
14. Small pocket screwdriver or instrument screwdriver.
15. 5/16" X 1/4" open-end wrench.
16. 7/16" X 3/8" open-end wrench.
17. 9/16" X 1/2" open-end wrench.
18. 3/4" X 5/8" open-end wrench.
19. Assorted nut drivers.
20. Set of Allen wrenches. Small fold-out kit works well.
21. Small hacksaw.

Miscellaneous:

1. Roll of Electricians plastic tape.
2. Pipe dope stick.
3. Four short lengths of 1/4" plastic tubing.
4. Assortment of 1/4", 10/24" and 8/32" nuts, bolts and washers.
5. Tie wraps.

Fittings:

1. 3/8" compression tees, couplings, and reducing couplings 3/8" to 1/4".

Fittings (continued)

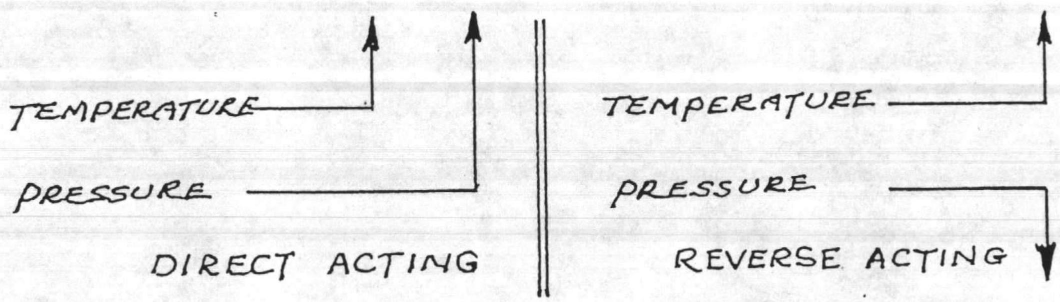
2. 1/4" compression tees, couplings, and reducing couplings.
3. 1/4" M.P.T. to 1/4" compression adapters.
4. 1/8" M.P.T. to 1/4" compression adapters.
5. 1/4" M.P.T. to 1/4" plastic barb fittings.
6. 3/8" barb couplings.
7. 3/8" barb tees.
8. 3/8" to 1/4" barb tees.
9. 1/4" barb couplings.
10. 1/4" barb tees.
11. 1/4" to 5/32" barb tees.
12. 5/32" barb couplings.
13. 5/32" barb tees.
14. 1/4" and 1/8" short pipe nipples.
15. Springs for inside 1/4" and 5/32" plastic tubing to prevent kinking.
16. 3/8" and 1/4" brass and plastic ferrules and inserts.
17. 3/8" and 1/4" rubber plugs.

Now that we have Main or Supply air to the system, we will next discuss Master and Sub-Master thermostats and controllers as associated with regulating the temperatures of the conditioned air. These can be called "Primary" controls because they are first in controlling the air to be used in air conditioning. These are the ones that are panel mounted in the air conditioning equipment rooms or spaces.

At this time you should become familiar with two very important terms used in control work. These terms are DIRECT ACTING and REVERSE ACTING.

When you read or hear these terms, always think of two names used to designate an action. For example, think of 1) Temperature and Pressure, or 2) Pressure and Pressure. When you think of two things traveling in the same direction, they are directly related so it would be "Direct" acting. If you have one thing going in one direction and another thing going in the opposite direction, they are reverse to each other, or "Reverse" acting.

The following two sketches will help to clarify these terms



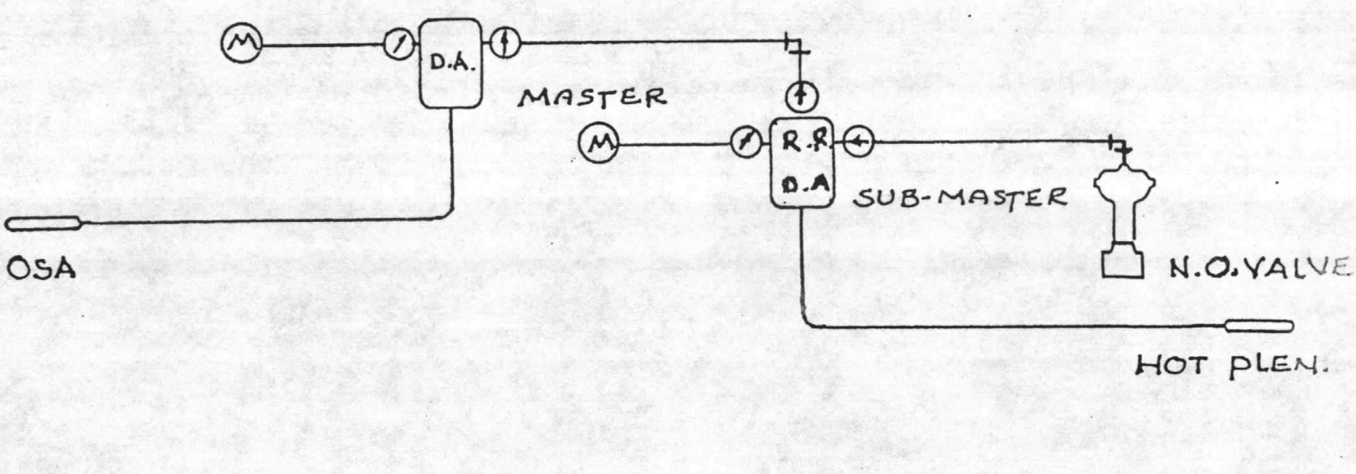
When you think of a master, you no doubt think of a boss, or one that tells the others what to do. This is exactly what a

"Master" thermostat does. So the master thermostat is the one that tells the sub-master thermostat what to do. It has a very important job to do, in fact, it takes the place of someone standing on duty to make a change in the setting of a sub-master thermostat when conditions change that make a change necessary.

One use of the "Master" thermostat is to sense changes in the outside air temperature and to raise or lower the hot or cold plenum temperatures by re-setting the sub-master thermostat.

This seems to be an appropriate time to explain two more terms that are constantly used in control work and these are NORMALLY OPEN and NORMALLY CLOSED. This has to do with valves, basically, and has caused some confusion in the minds of maintenance engineers. If a valve is open without air being applied to open it, it is a normally open valve. If it is closed without air being applied to it, it is a normally closed valve. Someone said that if the valve is open when you take it out of the carton it is a normally open valve.

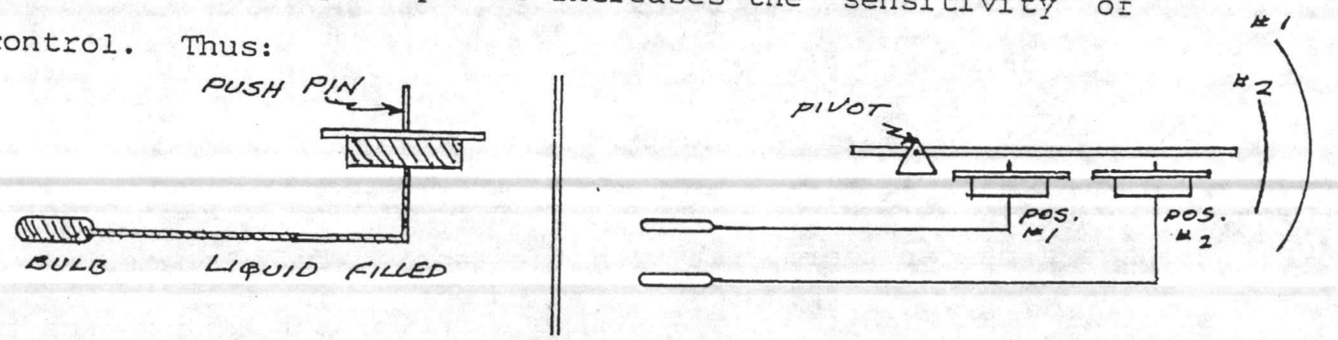
To get back to our master/sub-master combination, lets say we have a master thermostat with the sensing bulb located in Outside Air (OSA) and it is re-setting a sub-master that raises and lowers the temperature of the hot water for a heating coil. The sketch will show these two controls and the way they are connected:



As the OSA temperature rises, we want the temperature in the hot plenum to drop because not as much heat is required to heat the building.

This is a good economy feature as well as making the building temperature easier to control.

Some master thermostats have capillary tubes with a "Feeler" or sensing bulb on one end and a diaphram or bellows at the other end. The tube is sealed and contains a liquid or a gas that expands with an increase in temperature. Because the length of expansion is very small, many times only a few thousandths of an inch, levers are used to multiply this motion to where it can be used to operate the control. You can see on the sketch how moving the "push pin" away from the "pivot" will decerease the travel of the lever. Closer to the pivot makes the lever more sensitive to the motion of the push pin so increases the "sensitivity" of the control. Thus:



As the temperature increases at the bulb end of the capillary tube, the liquid or gas expands and pushes against the diaphram to allow the stat to increase or decrease the pressure output of the stat. If an increase in temperature at the bulb end occurs and an increase in output pressure of the stat occurs, the stat is said to be "direct acting". If an increase in temperature at the bulb occurs and a decrease in the output pressure occurs, the stat is said to be "reverse acting". Oftentimes, the location of the pivots in relation to the levers determines whether a stat is direct or reverse acting. These functions will be well demonstrated on the video tapes, so don't get too concerned at this point.

The following sketch will give you enough information to be able to understand the master/sub-master set-up.

RE-SET SCHEDULE	
OSA	HOT PLEN.
40°F. =	120°F.
60°F =	80°F.

You will notice on the sub-master stat R.R. and D.A. The reason for this is that the sub-master has two sections: 1) The action caused by the master stat, called the re-set readjustment, and 2) The action caused by the change in temperature at the bulb of the sub-master stat. Confusing? Not really, when you follow it through in a logical manner. D.A. means a direct acting sub-master. R.R. means a master that sets the sub-master down on an increase in temperature at the bulb of a master stat, this is reverse readjustment. For example, let's say that the OSA temperature is 40 degrees F. and the sub-master stat is controlling the hot plenum at 120 degrees F. Now, the OSA warms up to 60 degrees F. The output pressure leaving the master stat increases (because it is direct acting) to re-set the sub-master to lower the hot plenum temperature. The hot plenum temperature drops from 120 degrees to

80 degrees, and the sub-master now starts controlling at this lower temperature.

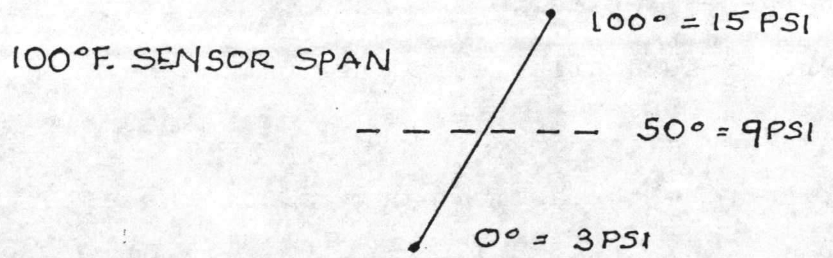
Two more terms: "TWO POSITION", or as some say "POSITIVE ACTING". This means that the output from a thermostat or controller would be either 0psi or 20psi. "PROPORTIONAL" or "MODULATING" means that any change in the temperature at the bulb would cause a proportional change in output pressure from the controller. In other words a gradual change.

Most control drawings have what is called a "set-up schedule" or a "re-set schedule" that shows the re-set and operating temperature conditions. The above re-set schedule would be the one we are using in our example.

Another term associated with control work is "<u>SET POINT</u>". This term means the point you set the control. If you set the dial or scale at 70 degrees, the set point is 70 degrees. If you change the setting to 75 degrees, you have changed the set point 5 degrees to 75. You can do this manually or it can be done automatically. In the master/sub-master combination, the set point is changed automatically by the master changing the set point of the sub-master.

In our example, the Master is turning the submaster down when the OSA temperature rises. So it is called direct acting reverse re-adjustment.

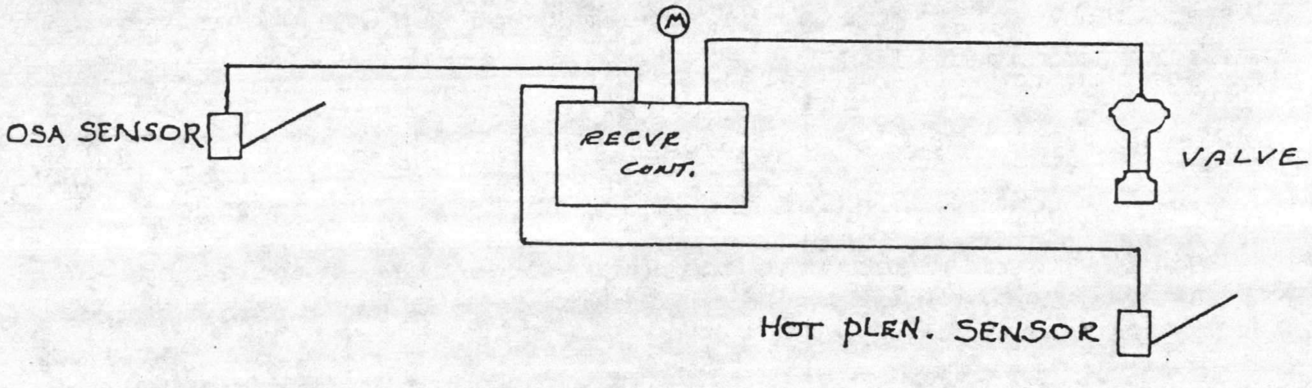
Some systems use a "Sensor" or a "TEMPERATURE TRANSMITTER" to re-set the sub-master. These controls usually have a fixed range or "SPAN". The span will be shown as 0 to 100 degrees, 25 to 125, 50 to 150, etc. For the most part, temperature transmitters are non-adjustable, but this depends on make and model of the device. The output pressure is linear which means a straight line of, say, 0 degrees would equal 3psi output and 100 degrees would equal 15 psi output. A simple sketch shows this:



Here is another sketch that shows how a sensor would be hooked into a sub-master stat that has another sensor in the hot plenum. Because these sub-master stats have no capillary tube they are usually called "Receiver/Controllers".

There are still some master/sub-master thermostats in use but the more modern system is the "Transmitter" to Receiver/Controller system. One advantage is in the fact that capillary length limits where you can mount an OSA stat but a transmitter in OSA can be connected to a receiver/controller by a piece of 1/4" plastic tubing a long distance away.

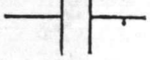
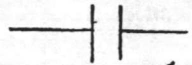
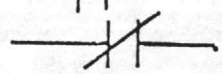
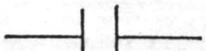
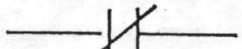
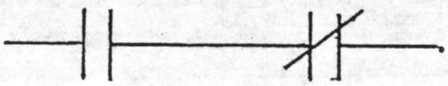
The equivalent of a master/submaster system using a receiver/controller might look like this:

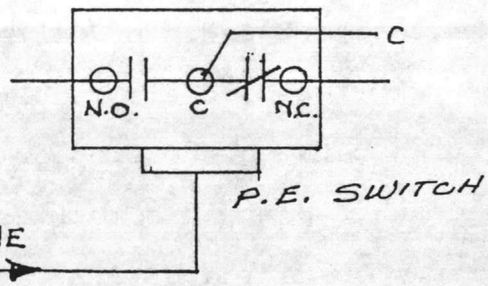


The OSA sensor, or transmitter, replaces the master stat and the hot plenum sensor replaces the capillary tube in the hot plenum. In the receiver/controller system, the command that one sensor has over the other sensor is often called the "AUTHORITY".

Please do not worry about all these actions and terms. The main thing to remember when replacing a control is, First, check the control drawing if it is available and set up the new control according to the drawing. If it says "Authority" 100% and "Proportional Band" 10%, set the replacement control at these settings before installing it...hook up the sensor lines, the branch line and the main air and all that is necessary is to adjust the setpoint to the conditions to bring it into control. If no control drawing is available, make a note of the settings on the defective control before you remove it and set the new control to these settings. If you have all black plastic tubing to the controller, it would be good to identify the sensor and branch line with tags or markers before disconnecting the old control.

One very important recommendation that we make is <u>not</u> to wind up with a "Heinz" system if you can possibly avoid it. A "Heinz" system goes something like this: A Honeywell sensor hooked to a Johnson controller feeding a Robertshaw relay to control a Powers valve. Stay with the same make of controls wherever possible, even in room thermostats!

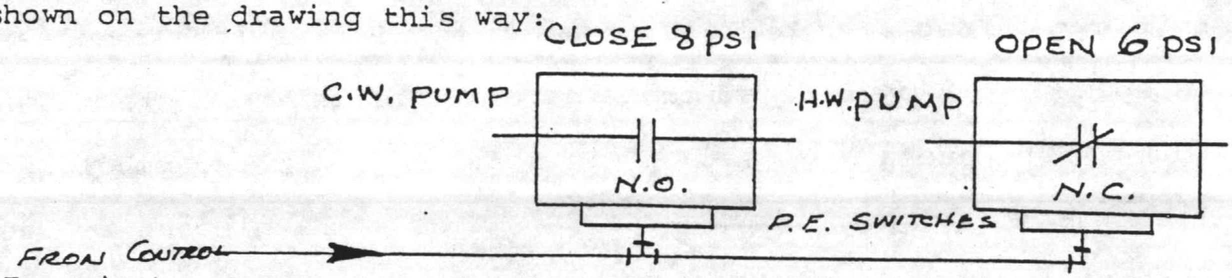
Now on to "PNEUMATIC SWITCHES" or P.E. switches: When you think of P.E. switches, think of the order they are listed under. The P. is first, which means that the P. or pressure is operating the E. or electrical, so a P.E. switch is an electrical switch that is operated by pressure. These P.E. switches can be adjusted to "Make" or "Break" electrical control on a rise or fall of air pressure. The symbol used to designate electrical contacts are:  To show an open contact the symbol  is used. A closed contact would be symbolized by this  So we have N.O.  & N.C. . A N.O. P.E. switch requires air to close it and a N.C.P.E. switch requires air to open it. Many P.E. switches have a dual set of contacts with both a N.O. and a N.C. set of contacts and would be symbolized like this:  To sketch this out as seen on a control drawing would look like this:



Here again we see the principle of pneumatic control in that we have a diaphram or bellows opposing a spring to actuate the switch.

There are usually two adjustments that can be made on a P.E. switch; one is the "Range" and the other is the "Differential". When the pressure increases from 0 psi to 10 psi and the switch "makes" it is said to have a "Cut In" point of 10 psi. As the pressure falls to 5 psi the switch "breaks" and is said to "Cut Out" at 5 psi.

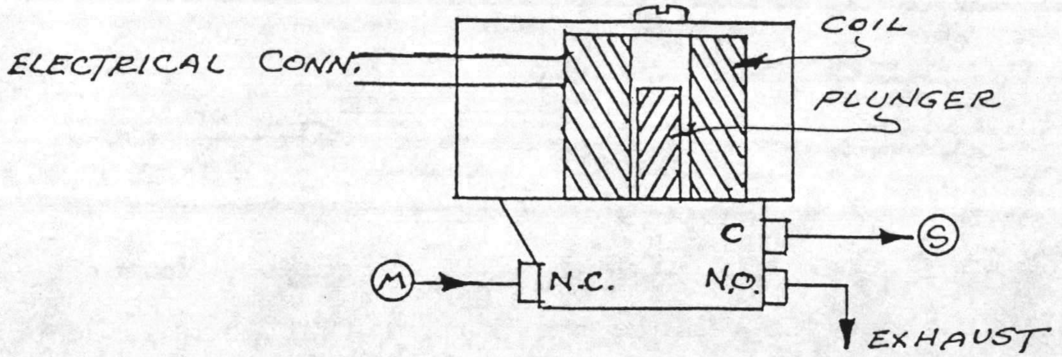
This means that the P.E. switch has a setting of "range" 5 to 10 psi and a "differential" of 5 psi. On a dual P.E. with one N.O. and one N.C. set of contacts, one "breaks" at the same time the other "makes". There are some more sophisticated P.E. switches that have a 'Lag" feature between "make and break". There are two switches connected to a common air source. These may be shown on the drawing this way:



P.E. switches have a great variety of uses in control systems such as to start and stop boilers, hot water pumps, chilled water pumps, chillers and air handling equipment, etc. The idle time or setting between the stop of a hot water pump and the start of a chilled water pump is sometimes called the "Dead Band", more on this later. Operation of P.E. switches will be covered in video demonstrations.

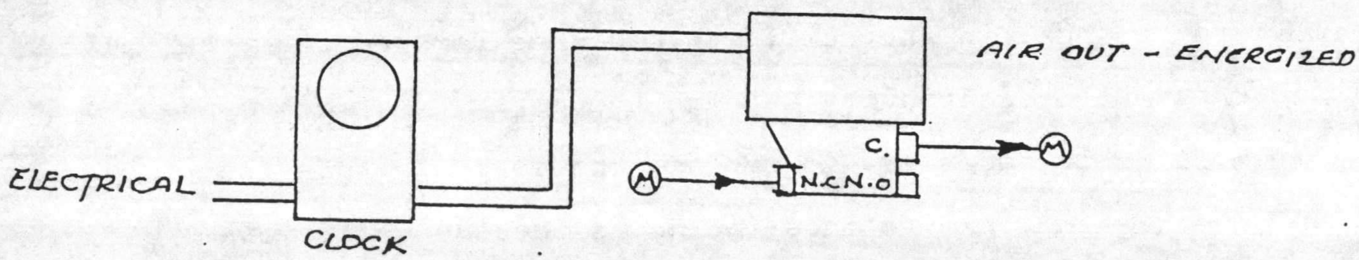
Do you remember the order of listing that we discussed in the previous explanation of P.E. switches? We said that whatever is mentioned first is the operating factor? Well now we will consider E.P. valves. In this device the E. or electrical is mentioned first so the electrical is operating the pneumatic.

In order to accomplish this, it is necessary for the electrical part to open the valve to let the pressure flow through the valve. It seems that the best way to do this is to use a magnetic field to "pull" the valve to an open position. This is accomplished by a "Pull-in" coil with a plunger in the center of it. The next sketch will explain:

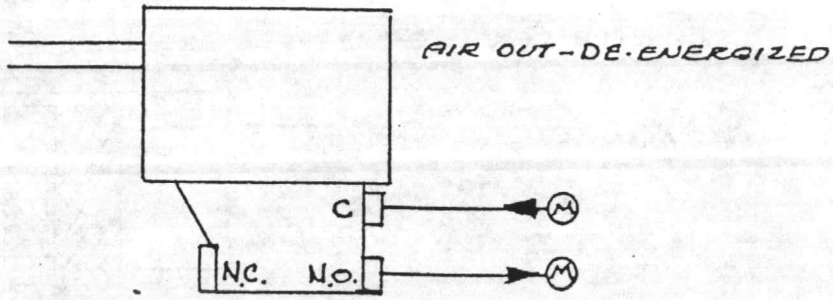


Another name for the E.P. valve is "SOLENOID AIR VALVE". The reason we have chosen not to use the symbol (S) in place of (M) is because many times "solenoid air" is sent out to the control system to furnish main air to only some of the controls and a regular main air to the rest. To avoid confusion, we separate the two.

If you wanted to have main air turned into a control system at a certain time of day, what better way than to set an electric time clock to energize the E.P. valve and turn on the main air. This E.P. valve can also be used to "LOCK-OUT" pumps or chillers or boilers and dampers, etc. Some of the ways these E.P. valves are used is shown:



They can be used to either put air on or bleed air off a device by the way they are piped into the system. Thus:



The only service possible on P.E. switches is minor. It is usually the best to replace the control that becomes defective. Oftentimes it is the Micro switch that fails or the linkage is just worn out. In the first case, it can be checked by a voltmeter or a continuity tester. If it fails at a different pressure each time it is pumped up with the squeeze bulb, it is usually worn-out linkage. If the diaphram or bellows does not hold air from the squeeze bulb, there is usually nothing that can be done except to replace the whole P.E. switch.

The check an E.P. valve, the first thing to do is to feel the coil section to see if it is warm. (It can be very hot, so touch carefully.) If it is cool, check to see if there is electrical voltage to the coil. First try holding a small screwdriver on top of the coil screw and see if you feel a magnetic pull. If not, still use the voltmeter to be sure. If there is power to the coil but no heat in the coil, it should be removed from the valve and checked for continuity through the coil.

If it is necessary to replace the coil, be sure that the new one has the same voltage rating as the one you removed. If the voltage is wrong, the coil will either buzz real loud or fry.

Assuming that the E.P. valve is warm but there is no air leaving the "out" port or connection; if there is air at the 'in" port and no air at the out port, either the filters inside the "in" port are plugged or the inside plunger is not opening the valve. In either case, most of the valve bodies can be taken apart, inspected, cleaned and repaired unless totally worn out. You will see these valves broken down on the tape.

It is time now to see the taped demonstrations and displays on TAPE #1-B. If you do this, it will help greatly when you take the following written review.

Note: Please do not take this written review until after you have viewed tape #1-B.

1. Where do we usually find Primary controls in an air-conditioning system?

____

2. What two terms are very important in the Master/Sub-master control relationship?

______________________ and ______________________

3. Direct Acting means ______________________
Reverse Acting means ______________________

4. A Normally Open Valve (N.O.) is a valve that is __________ with no air on it.

A Normally Closed Valve (N.C.) is a vlave that is __________ with no air on it.

5. There are two reasons why a Master stat in OSA and a sub-master stat is used in heating. What are the two reasons?

______________________ and ______________________

6. Even though the motion created by a capillary tube may be only in thousandths of an inch, how can this motion be used to actuate a control?

____

7. How is it possible to determine if a control is direct or reverse acting?

____

8. If a sub-master control is designated on the control drawing D.A./R.R., what does this mean?

____

9. From a control drawing, how do you know how to set up a Master/sub-master combination?

____

10. What is meant by set point? ______________________________

11. Some control companies use the term "Transmitter" and others use the term "Sensor". If this device has a span of 100 degrees and operates between the pressures of 3 to 15psi, what is the relationship of pressure to temp?

____

12. Even though there are some Master/sub-master controls in use today, what is the more modern equipment that does the same thing?

A ______________________ connected to a ____________________

13. What does "Authority" mean?

____

14. If you have to replace a controller and no control drawing is available, what is recommended?

____

15. How do you keep plastic lines, that are all the same color, from getting mixed up when changing a controller?

____

16. Mis-match can occur if you use a variety of manufacturers controls, called a "Heinz" system, so what is recommended?

____

17. Still under this #1-B heading, we have P.E. switches and E.P. valves. What does each designation stand for?

P.E. ______________________________
E.P. ______________________________

18. What does a P.E. switch do?

____

19. What does a E.P. valve do?

____

20. Can you think of another name for an E.P. valve?

____

21. If you have to replace the pull in coil in an E.P. valve, what caution must be taken?

____

LETS GO ON TO THE NEXT SECTION ÷2-A.

Previously we discussed Capillary tubes and Sensors, but we feel that they are so important in control work that we are going to carry the discussion still farther.

We mentioned that Capillary tubes (cap. tubes) come in varying lengths, but it is a known fact that the longer the capillary, the slower response to temperature changes at the "feeler" or "sensing" bulb. It can be a real advantage to locate a control having a capillary tube as close to the temperature conditions that we are sensing as possible. In other words, the shorter the capillary, the better.

There are capillary tubes on many controls and thermometers, and it is good to be able to observe if they are doing their job. Lets say that you have a cap. tube that you find does not hold its set point or calibration over a period of time. No doubt, the cap. tube is going "soft" or getting "soggy" or just losing its charge of gas or liquid in the element. If this "drifting" occurs, you will have to keep changing the set-point of the control, or in the case of a thermometer with a cap. tube, the pointer will have to be re-set frequently.

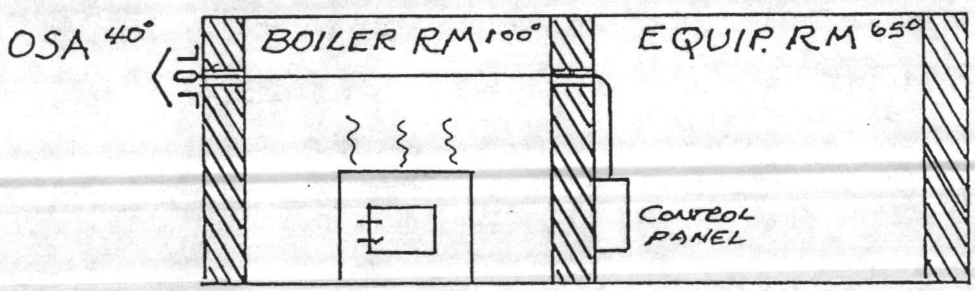
In the case of a control having a capillary, it is a good idea to put a red pencil mark on the set point dial opposite the indicator when you know the control is in calibration. Later, after a quick check, you find that you have to move the set point dial away from your mark to bring the control back into calibration, it is a good indication that the cap. tube has drifted and is losing its charge. A cap. tube cannot be recharged, so must be replaced if possible.

Controls with replaceable cap. tubes may have these available in a variety of lengths. There are 3, 6, 8, 10, 15, and 25 foot lengths available as standard.

Special lengths are sometimes available from the control companies on special order.

There have been different types of cap. tubes used by control companies and among these are: Remote Bulb, Standard Copper, Compensated, etc. "Compensated" means that the sensing is done at the bulb end only and not affected by different temperatures along the length of the tube. Usually the compensated cap. tubes can be identified by the fact that the tube section is stainless steel instead of copper.

In the next sketch you can see the advantage of a "Compensated" cap. tube as it runs through a hot boiler room to an equipment room from OSA.

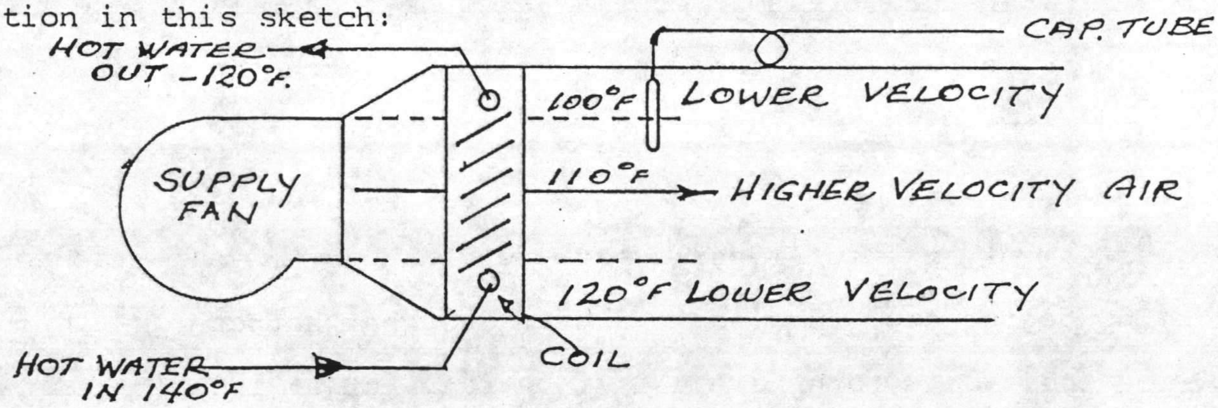


A "Non-Compensated" capillary tube could be affected by the changes in boiler room and equipment room temperatures.

A "Temperature Transmitter" or a "Sensor" in OSA with just the plastic or copper tubing passing through the two different temperature rooms would not be affected by this temperature change.

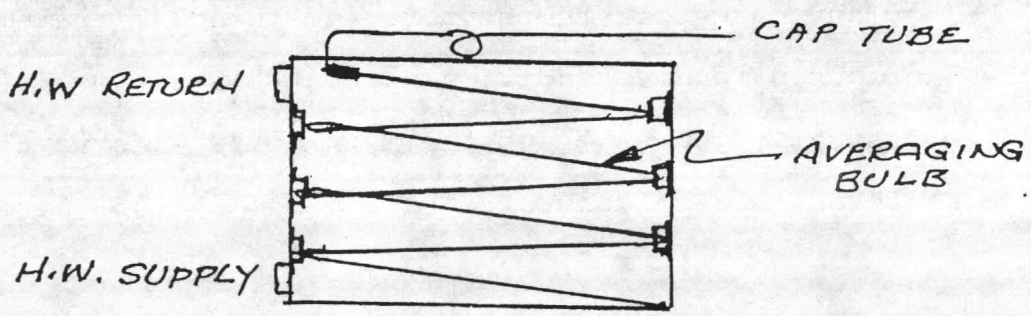
Also another capillary tube in wide use in air conditioning systems is the "Averaging" type. This cap. tube has a "Feeler" or "Sensing" section that receives the average temperatures of the entire length of the bulb or feeler.

There are conditions that occur in air movement by fans and blowers that make the averaging cap. tube very useful. For example, lets say that we have a supply fan blowing air through a heating or cooling coil and we want to control the temperature of the air in the discharge plenum leaving the coil. Because of what is called "Stratification" or "Sandwiching" of the air, we may have different temperatures and velocities of the air leaving the coil. Also the water entering the coil will be a different temp. than the water leaving the coil. (Entering water is called "Supply" and leaving water is called "Return"). Notice this condition in this sketch:



Because of these variable conditions, it is almost impossible to accurately control the temperature of the leaving air.

Now we are going to look at the leaving side of the coil and face it with the air blowing directly at us, so that we can see the way an averaging cap. tube is used:



This cap. tube is sensing over the entire length of its bulb. The averaging bulb is not in direct contact with the coil, but is supported by a rack or clips in free air.

If you have a great number of "Primary" controls in your building to service, you may want to build a simple "Hot Box" like the one used in the taped demonstrations to check cap. tubes and sensors. All you need is 1) 1--1/2" plywood, 2) a hair dryer, and 3) a dial thermometer.

TEMPERATURE TRANSMITTERS OR SENSORS:

Temperature transmitters may also have capillary tubes. When this is the case, the cap. tubes must match the control, as we have mentioned. If you have a 0 to 100 degree transmitter, which means that at 0 degrees it will put out 3psi and at 100 degrees it will put out 15psi, what would happen if you attach a 0 to 200 degree cap. tube to it? Lets see what happens. At 0 degrees they would both have a 3psi output, but at 100 degrees one would have a 15psi output but the other would have only a 9psi output. So we could say that the cap. tube in the latter case would not be matched to the temp. transmitter.

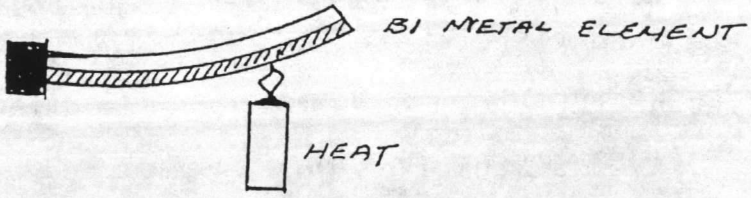
Usually, there is a tag or label on the transmitter showing the range.

There are both temperature and humidity transmitters and sensors used in air conditioning control systems. The mechanics are basically the same and the main difference is the sensing elements used in each control. In the sensing of thermostats we have cap. tubes, expanding "Rod and Tube" metals and bi-metals. In the humidity sensors we have "Membranes" consisting of hair, nylon and wood, etc.

A humidistat senses moisture changes and raises or lowers its output pressure according to whether it is direct or reverse acting. A direct acting would increase its pressure output on a rise in humidity and a reverse acting humidistat would decrease its output on a rise in humidity. The membrane of a humidistat expands on an increase in humidity and shrinks, or contracts, with a decrease of humidity.

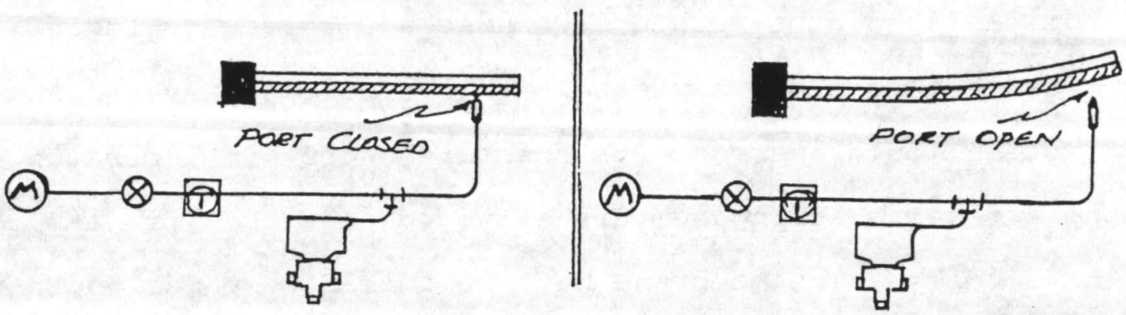
Return air duct mounted humidistats are usually much more effective in controlling humidity than room or wall-mounted humidistats. The reason for this is that a humidistat in slow-moving air, such as in a room or space, does not react as quickly as one that has a volume of air passing through it. Rooms with good air circulation, or many air changes, can use wall-mounted Ⓗ stats quite effectively.

To illustrate the motion caused by sensing elements, the sketches will show the motion produced by these elements. This motion is, of course, exaggerated to make it easier to visualize. Thus:

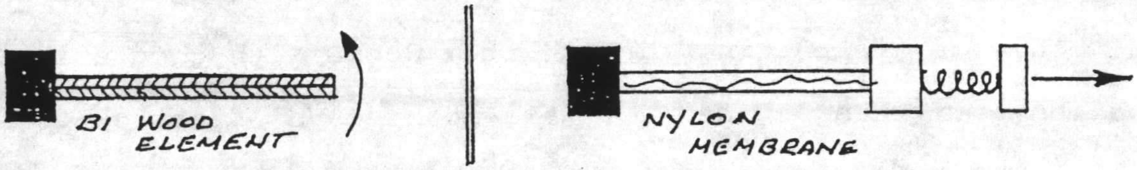


As you can see, the "large" expanding metal will push the "small" expanding metal and bend it or warp it. These two metal, or "Bi-metal" elements are very widely used in thermostats.

Now, lets see how this method is used in a one-pipe temp. transmitter for space or room control.

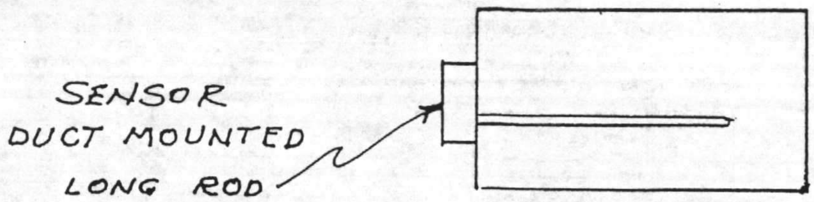


In a humidity transmitter or humidistat, a Bi-wood element could be used to replace the bi-metal one used in thermostats. This means that two different woods are fused together that have different expansion characteristics with a change in humidity. Sometimes the motion is a "Stretch" rather than a bend as in the case of hair or nylon membranes. Another sketch:



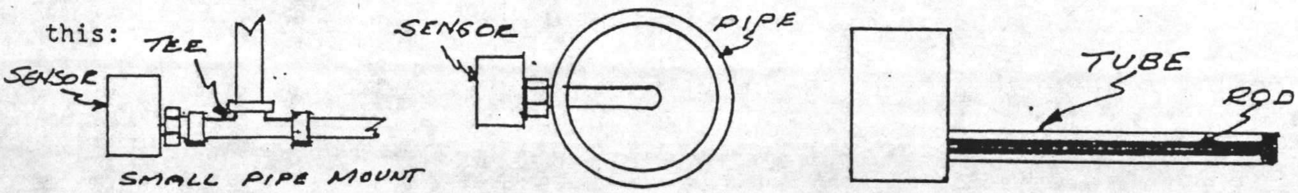
Another type of sensor called the "Rod and Tube" sensor has been used by some control manufacturers with good success. These come in different lengths according to the place they are to be used. There are long ones that are usually the duct-mounted type and the short ones that are used inside the piping system.

When a sensor is "duct-" mounted, usually all that is required is to make a hole in the duct and screw the sensor to the duct. In "pipe-" mounted sensors for water, it requires a "well" or socket to put the sensing end in. These wells ordinarily have a pipe thread that screws into coupling that is welded on to the pipe or that screws into a pipe fitting. This shows the two types of rod and tube sensor mounting:



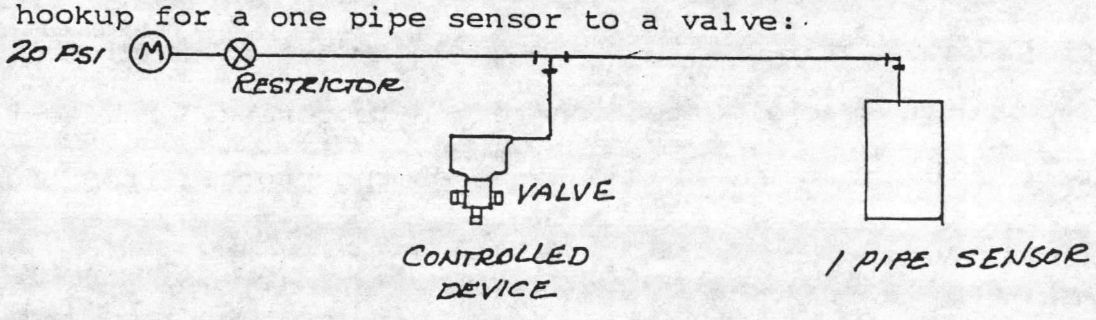
Wells may be made of different metals; copper or brass, that transfer heat very readily are often used. When the well is subject to liquid that is corrosive or abrasive, stainless steel wells are often used.

If we were to look at a rod and tube element, it may look something like this:

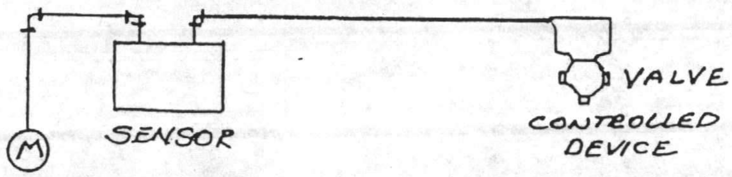


The outside tube expands and contracts lengthwise, pulling the rod to create a motion that can be used to actuate a control or sensor. The chalk board presentation will explain the operation.

Sensors and transmitters can be what is called "One pipe" or "two pipe". The one pipe sensor requires a restrictor between the (M) air and the controlled device. Here again, the restrictor used has to match the sensor or the sensor output will not be right. This is the hookup for a one pipe sensor to a valve:



The "two pipe" sensor has a (M) air connected to it and the leaving or (Br) branch air varies in the sensor according to temp. change at the sensing element. Sketch:



The operation of room thermostats and humidistats will be covered in greater detail in the section "Calibration", but you can see why we wanted to spend more time with capillarys and sensors. They need to be functioning properly in the control system or we do not have control over anything.

Before trying to calibrate or set-up any control system, be sure that these devices are doing their job properly.

In starting to go through your control system, we would like you to think about this: Lets say that you have a "primary" control panel having OSA re-set that you want to start calibrating. You look at the thermometer on the panel marked OSA. Using this OSA thermometer to set the controls is the way to go, but what if the OSA thermometer is 20 degrees off from the correct OSA temperature? You may do the best job possible of calibration, but the whole thing won't work properly if you have set it up to a bad OSA thermometer. So, always start at the beginning to set up a control system - not in the middle or the tail end.

Give special attention to the temperature read-out thermometers or the temp. read-out gauges and proceed from there. Start

OSA, to return air, to mixed air, to plenum or discharge temperatures, reading and correcting (if it is necessary) these temperature readings and you are well on your way to a proper set-up of primary controls.

IT IS AGAIN TIME TO SEE THE TAPED DEMONSTRATIONS AND DISPLAYS FOUND ON TAPE #2-A

TAPE #2-A

Note: Please do not take this written review until after you have viewed tape #2-A.

1. When replacing a capillary tube on a control, having a cap. tube, why is a shorter cap. tube better?

____

2. How do you detect a capillary tube that is going bad?

____

3. What is the difference between a "Compensated" and a "Non-compensated" cap. tube?

____

4. Where would a "compensated" cap. tube work better?

____

5. What is an "Averaging" cap. tube?

____

____

6. Where would an averaging cap. tube work better than a short bulb type?

____

7. A temperature transmitter, or sensor, has a cap. tube. Why must the cap. tube range, or span, match the span of the sensor?

____

8. What is the main difference between a temperature sensor and a humidity sensor?

____

9. How does a "Bi-metal" thermostat element work?

____

10. Name some of the "membranes" used to sense a change in humidity.

____

____

11. "Rod and tube" sensors are in wide use in pneumatic control systems. When would you use a long rod sensor?

____

When would you use a short rod sensor?

____

12. What is the difference between a "One pipe" and a "Two pipe" transmitter or sensor?

____

13. When you plan to go through a complete calibration of the "Primary" controls of a pneumatic control system, where is it best to start?

____

14. Explain why you would start at this point first.

____

____

LETS GO ON TO THE NEXT SECTION #2-B.

In automotive air conditioning, they have what is known as "Doors". These doors divert or change the path of air, from the blower, through either the heating coil or cooling coil or ventilation system. These doors are operated by small motors called "door motors".

In building air conditioning we call the equivalent to these doors "Louvers" or "Dampers". To operate these dampers we have "DAMPER MOTORS".

Control companies have different names for these damper motors, such as "Power Stroke" motors, "Piston Actuators", "Damper Operators" and "Damper Motors". For our discussions, we are going to use the simple term "Damper Motor" for these devices.

These motors are used in a great variety of places in air conditioning systems as we shall see, and from our discussion and demonstrations, you should become thoroughly familiar with their use and operation.

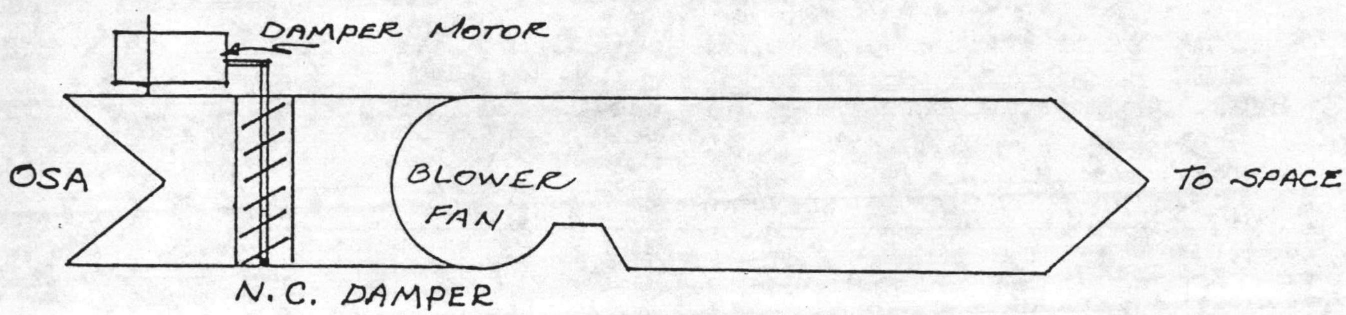
Starting with the OSA intake, there will be one, possibly even more, dampers with damper motors linked to or connected to OSA dampers. There may be a "MAIN" OSA damper and what is called a "Minimum" OSA damper that are connected by two different damper motors. For our discussion we may abbreviate "Piston Damper Motor" as P.D.M.

As we follow the air through the building air conditioning system, we may find a "Return Air Damper". Many systems have "Exhaust Air Dampers" that allow the building return air to be discharged or exhausted out of the building. Progressing through the air conditioning system, we may have what is called "Face and By-pass dampers" which allow air to go through a coil; and open face damper or a by-pass damper when open allows the air to go around, or by-pass, the coil.

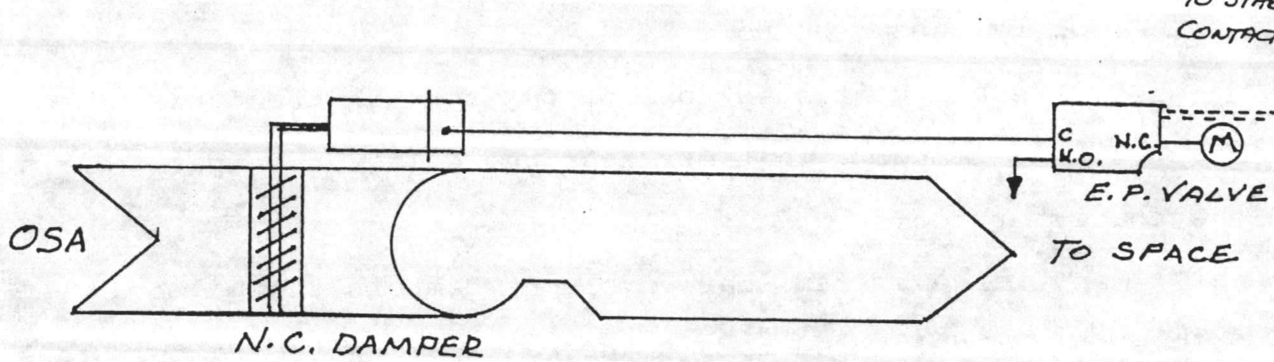
As the air continues to flow out through the ducts we may have "Mixing Dampers" that mix heat and cold for tempered air to the spaces or rooms.

Many large systems have "Volume" dampers that control the volume of air delivered to a space. Also "Static" dampers that control the pressure of the air in the supply ducts.

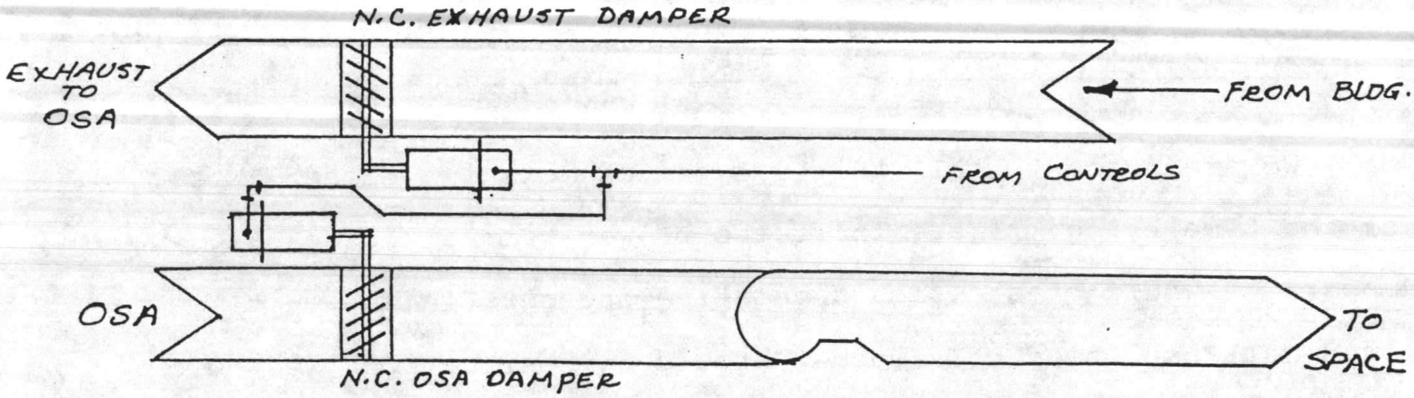
Lets go back and, by a series of sketches that could be connected together, see the position and operation of each of these dampers in a full automated damper system. To start with, we have a "Blower Fan" pulling in OSA and pushing it through the system. Thus:



We are going to call this OSA damper Normally Closed (N.C.) for the time being. If we start the blower with a closed OSA damper, we would create such a negative pressure in the duct, we could collapse the duct. To get around this situation, we would have to be sure that the damper opens when the blower starts. This can be done by adding an E.P. valve that is tied in electrically to the blower starting contactor. This E.P. valve would open, when the blower starts, and put (M) air pressure to the damper motor to open the OSA damper, as shown in this sketch:



It is quite evident that this system would not work properly because we are blowing air into the building with no place for it to go. The building would become "Pressurized" to the point that doors to the outside of the building would stand part-way open trying to relieve the air. This is called "High Static" condition. To correct this condition we install an air 'Exhaust' duct, damper and motorize it with another damper motor that would open this exhaust damper the same time that the OSA damper opens. Now we would have:

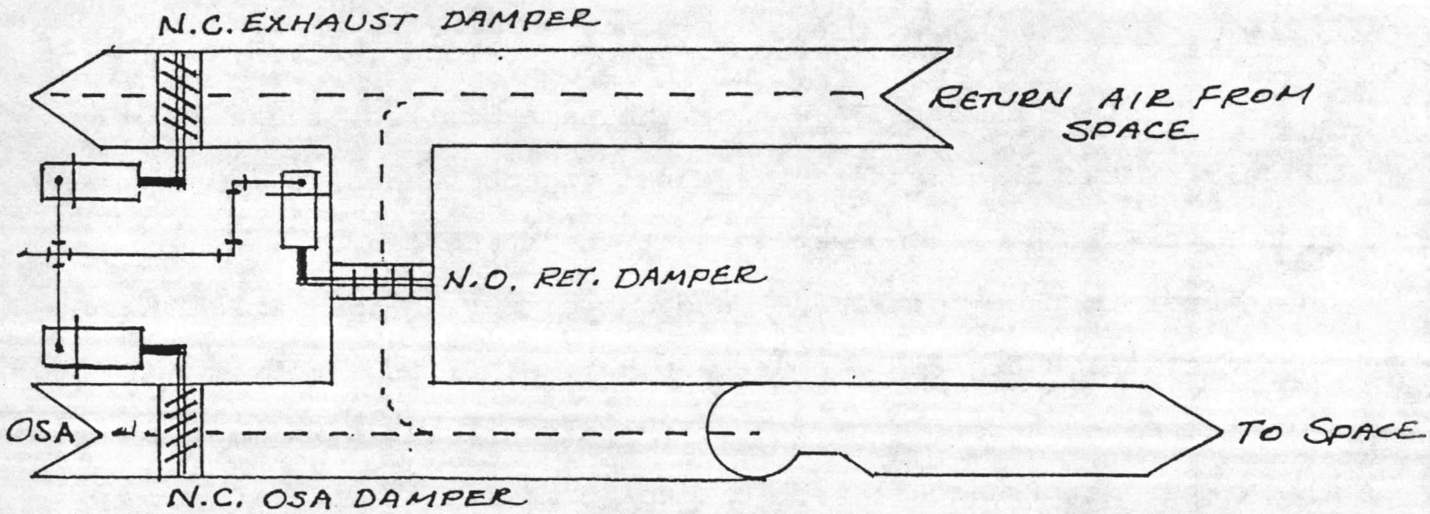


So, as the blower starts, the two dampers open and the air is able to move in and out of the building properly.

This type of system could be used for spaces where recirculated air would be objectionable, such as laboratories, some hospital areas and spaces where contaminants are used in manufacturing, etc.

As you can see, this system would not be very cost-efficient because the OSA may be very cold and it would take a lot of energy to warm it up or it may be very warm and require a lot of energy to cool it down to a temperature that could be used in the building.

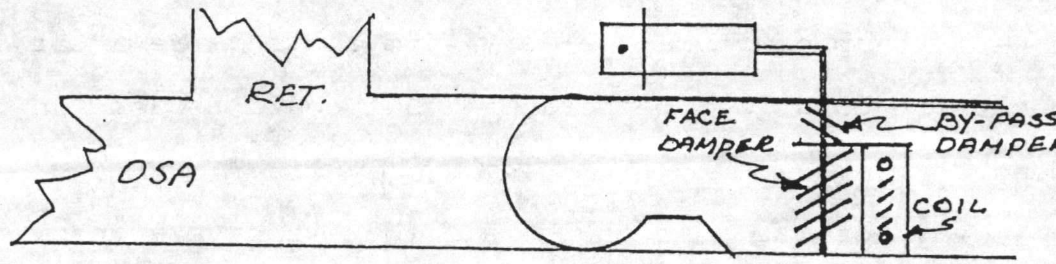
So why not use some of the air that we have already cooled or heated to save energy and reduce the amount of heating or cooling capacity needed to maintain a good condition in the building space? We do this by adding a "Return" air system to our OSA and Exhaust system. To make this an automatic system we can do this:



This automatic system has also been called an "Economizer System" and is controlled by the type of controls that sense the OSA and the Return or, oftentimes, the Mixed air to position the dampers.

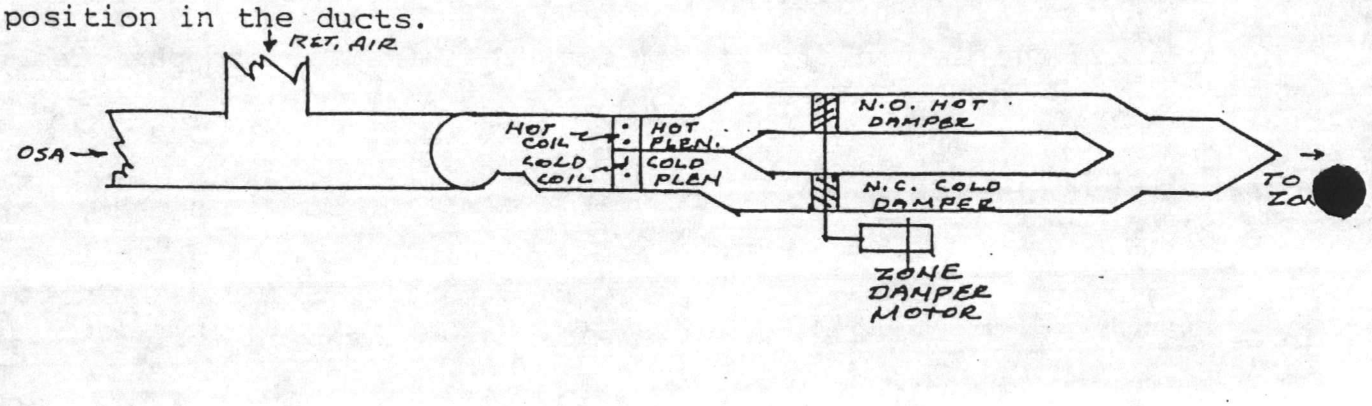
When we discuss "Thermostats" in a coming section, you will see how these dampers are automated to keep the air balance and aid in controlling air temperature.

The next sketch will show a "Face and By-pass" set of dampers and their position in an "Air Handling" unit that has a blower and heat/cool coils.

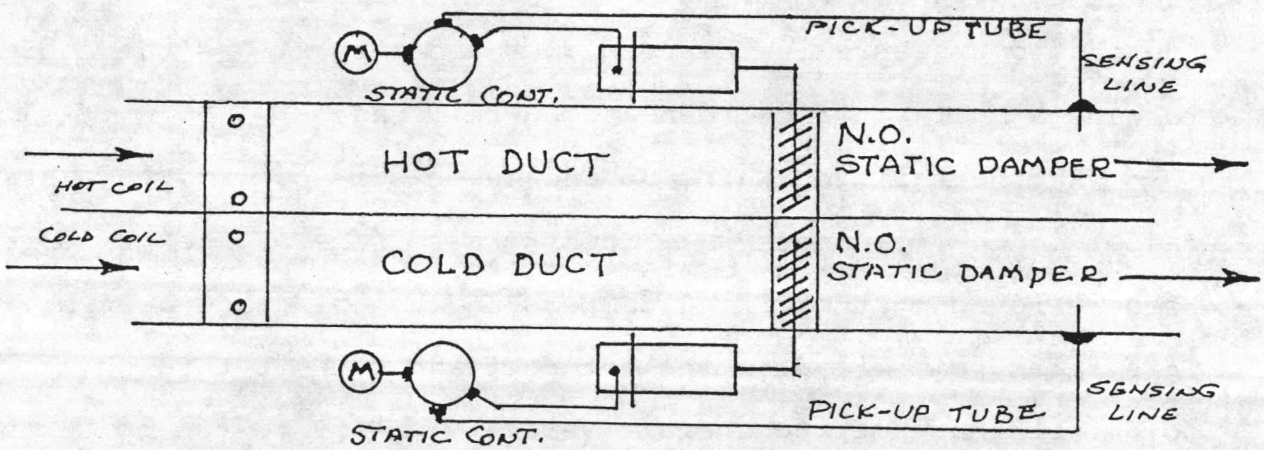


The Face and By-pass dampers are 90 degrees from each other and linked together so that as one opens, the other closes. They are usually driven or operated by one damper motor. Not all systems have these face and by-pass type dampers.

Carrying our illustration of dampers along farther, we come to the "Mixing" dampers. Just as the name implies, these dampers mix air of two different temperatures together to allow the system to deliver air at a temperature that the space can use. There is one damper in the "Hot Plenum" and one damper in the "Cold Plenum" that operate 90 degrees from each other. This is accomplished by having the hot and cold dampers both on one shaft. In most cases, the damper motors are linked to a hot damper that is N.O. and a cold damper that is N.C.; but this is not always the case. Notice their position in the ducts.



The final set of dampers we will discuss are the "Static" dampers. These are used on larger systems having long runs of hot or cold ducts or as some say "Extended Plenums". These may look somewhat like the mixing dampers but have a different purpose. "Static" is actually the pressure against the inside of the ducts and not the air flow through the ducts. Air flow is "Velocity" or movement of air. The reason for static dampers is to maintain a constant static or pressure in the hot and cold ducts which also keeps the volume of air from varying too much as it comes out of the air supply "Grills or Registers" into the air-conditioned spaces. These dampers should never completely close but can throttle down to a minimum for good control. They are connected N.O. and are controlled from two different motors. The sketch will show their position in the duct work and how the "Static Controller" is connected to operate the dampers.



When the mixing dampers are not built into the air handler, they are usually "tapped" into the hot and cold ducts close by the space they serve and mix the air in these hot and cold ducts as required by the space or room thermostat. These can be individually controlled from a single thermostat or one thermostat can be connected to several mixing damper motors that make up one zone.

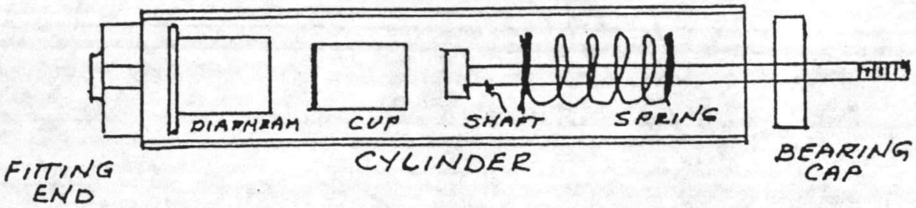
Back to the static controller for a moment; it has a sensing line that is stabbed into the duct downstream from the static damper and senses any change in static pressure in the duct. As the pressure in the duct increases, the controller starts to close down the static damper causing less air to flow in the duct.

Lets create a condition and see what "Static" dampers do. We have a cold building and the room (T) stats have all the hot mixing dampers open and the cold mixing dampers closed - calling for full heat in the rooms. At this condition we need a lot of air flow through the hot duct and no air flow through the cold duct because all cold dampers are closed. The static controller in the cold duct senses the high pressure in the cold duct because the blower is blowing into a closed duct, and closes down or "throttles" the static damper for the cold duct. This reduces the static pressure in the cold duct and also allows the hot duct to have a full air flow to heat the building.

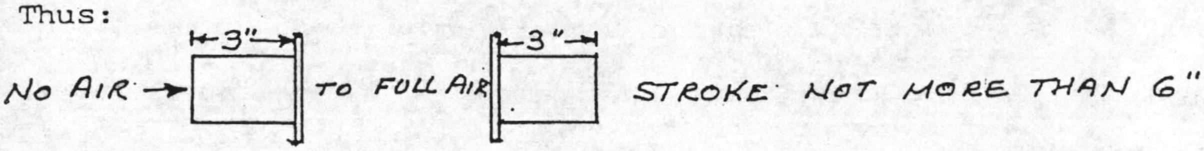
As the building warms up and needs some cooling, the static damper on the cold duct will open because some of the pressure has been relieved by the mixing dampers on the cold side opening. This takes some air from the hot duct and puts it through the cold duct thus keeping the air velocity of air to the space in balance.

We now get back to "Damper Motors" and observe the construction and operation of a damper motor. Here again in this device we have an excellent example of the principle of pneumatic controls - air pressure opposing spring pressure to create motion.

Starting with a metal cylinder, we add a shaft, a spring, a metal cup and a diaphram and we have a damper motor. This is one way one might be broken down to show these parts:



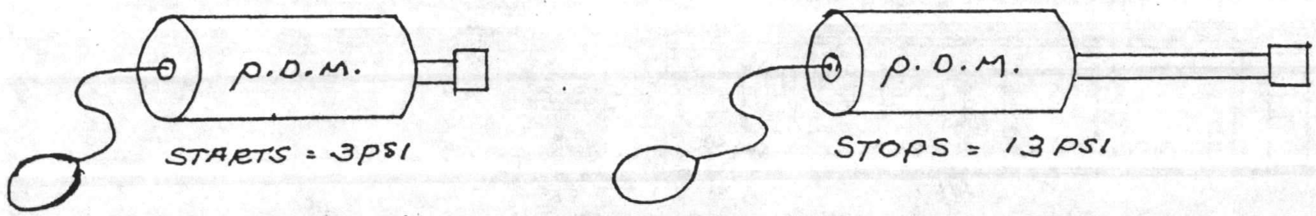
The rubber diaphram may look like an old-fashioned stove-pipe hat and it turns inside out when air pressure is applied to it. Thus:



The "Stroke" or the travel of the damper motor shaft can be no greater than the length of the diaphram from no-air to full-air positions. Different springs are what govern the start and stop of travel of the shaft in and out of the "P.D.M." (Piston Damper Motor).

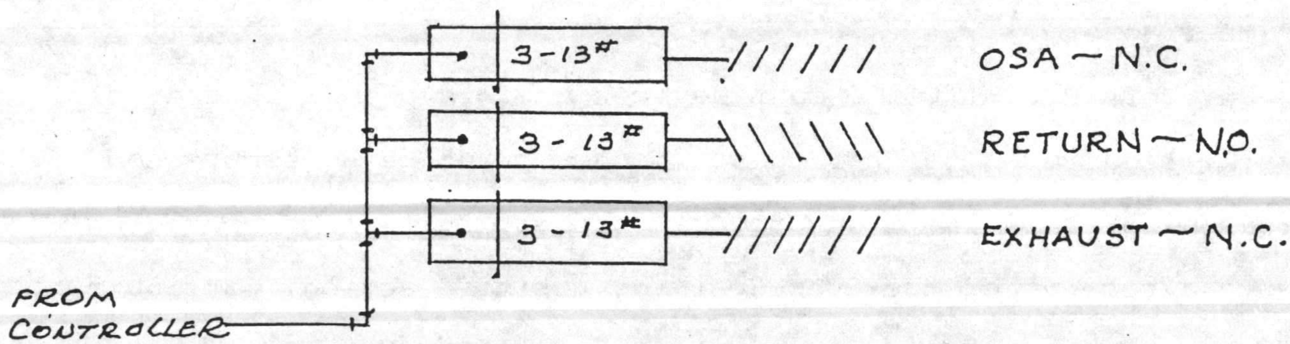
This P.D.M., like most devices used in pneumatic control work, requires 2 to 3psi to start the spring being compressed. The reason for this is to insure full-open or full-closed positions with a reserve of the 2 to 3psi for positive action. Spring ranges vary in the start and stop travel used in P.D.M.s and some spring "Ranges" are 3 to 13psi, 4 to 8psi, 5 to 10psi, etc.

If you are not sure of the spring range of a P.D.M., simply hook up a 'Squeeze Bulb' to it and pump air into it. The point where the shaft just starts to move is the "start" pressure of the spring and as you continue to pump more air pressure into the motor, the point where the shaft stops moving is the "stop" pressure of the spring. Lets illustrate this:

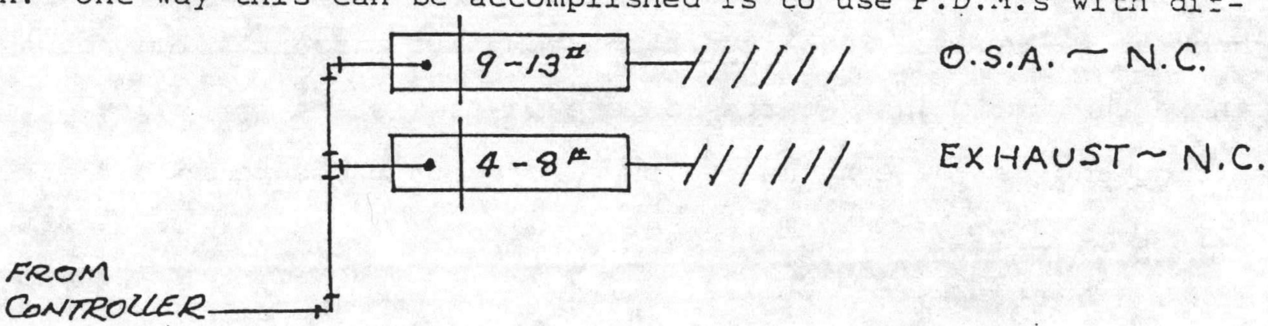


The spring in our example is a 3 to 13psi spring, so it has a range of 10psi from start to stop. Some manufacturers of damper motors have models of P.D.M.s that have "spring adjusters" in them that can be adjusted to change either the start point or the stop point by changing the spring tension.

Spring ranges in P.D.M.s used in combinations like OSA, Return and Exhaust damper operation should match, or in other words, the motors used to operate these dampers should work together and start and stop the same. Sketch shows how this is accomplished:

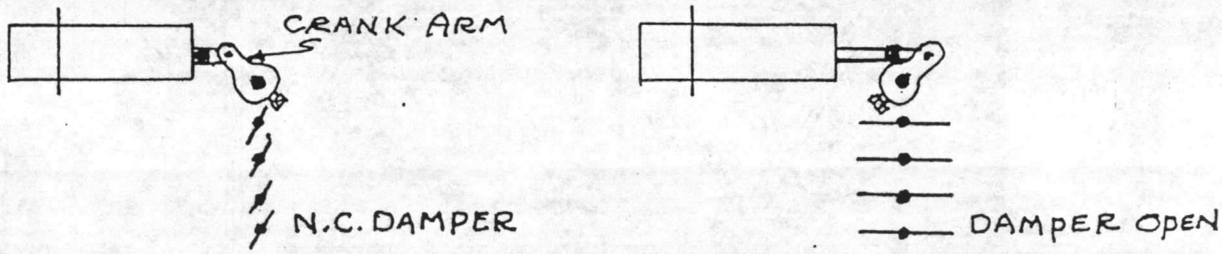


There are times when we may want to "Sequence" damper operation or have one damper start to open after another damper is fully open. One way this can be accomplished is to use P.D.M.s with dif-



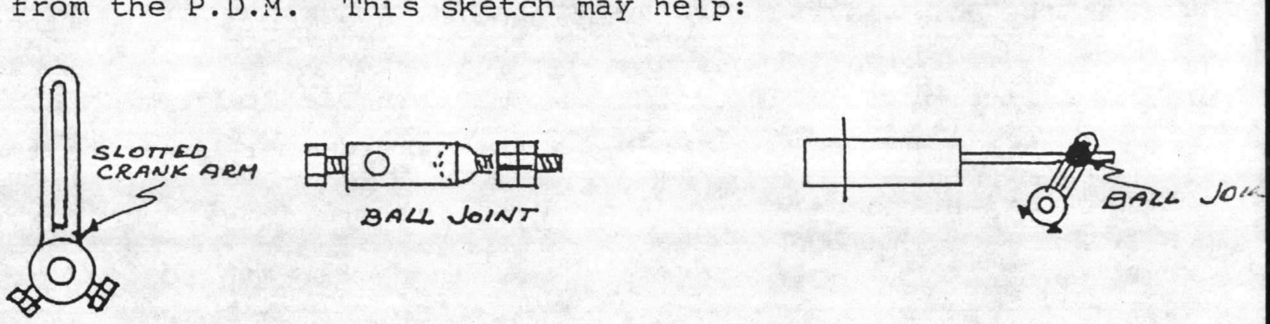
As you can see, the 4 to 8psi damper motor would have the exhaust damper fully open before the OSA damper with a 9 to 13psi spring would start to open.

As we mentioned, the dampers we operate often need to operate or travel 90 degrees from closed to full open. To operate a damper, we have to change the in and out motion of the damper motor shaft to a rotating motion of the damper shaft. To accomplish this, a "Crank Arm" is bolted on to the damper shaft and the P.D.M. shaft is connected to this crank arm. You will see in the drawing how this is accomplished.

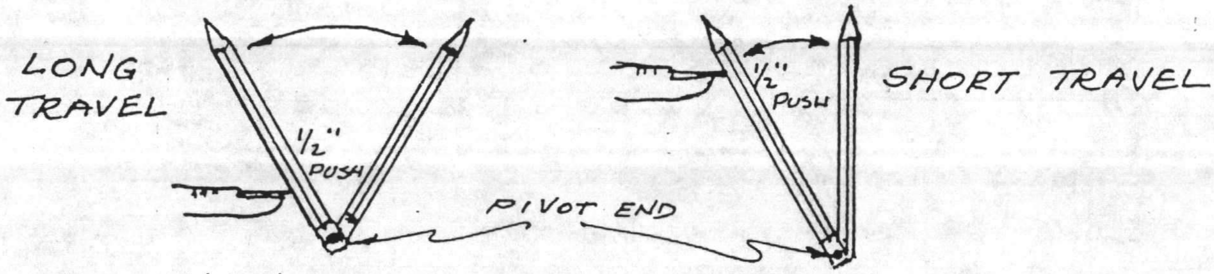


Some "Crank Arms" are matched to the damper motor and, without changing the travel or the factory adjustment, are exactly 90 degrees in travel. This means that with a number 4 P.D.M., you would use a number 4 crank arm.

There are many combinations that can be used such as a "slotted" crank arm that will allow a great variety of travel angles and damper openings. The slotted arm usually has what is called a "Ball Joint" that is bolted to the crank arm and receives the rod from the P.D.M. This sketch may help:



The closer the ball joint is to the damper shaft, the more rotation of the damper shaft, for the same amount of travel of the P.D.M. shaft. Confused? Try this - hold a pencil by the eraser end and move it with a finger from the other hand 1/2" close to the pivot or eraser end and you will find that the travel of the other end of the pencil is quite long. Now, still holding the pencil by the eraser end, move the pushing finger away from the pivot or eraser end close to the other end of the pencil and you will find that the travel of the pencil will be much less. Notice the sketch on this:

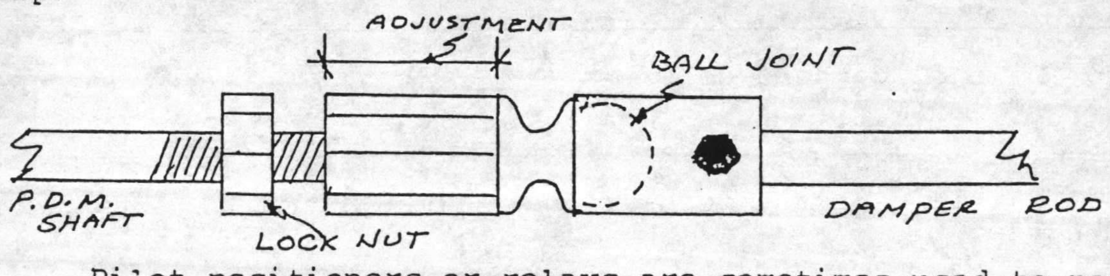


When adjusting damper travel, or movement, first make sure that the damper is free, or moves without binding, sticking or drag. To check this it is best to disconnect the damper linkage and move it by hand, using the crank arm as a lever. If it is not free, it is recommended that it be worked all the way through its travel using a good solvent or light oil as you move it. Dampers have different types of bushings that the shafts pass through and for the metal bushings you might try a light oil with graphite mixed with the oil. Once it is easily moved by hand, you can re-link the linkage and the motor should move the damper without any problem.

If it is a N.C. damper, rotate the damper shaft to the closed position and connect the linkage to the P.D.M. with no air on the motor. Next put full air on the motor and watch the travel. If the damper opens fully at the end of the stroke, without straining the linkage, it is O.K. If the damper opens before the end of the travel of the damper motor it has to be adjusted. The travel should not strain or force the damper or linkage.

There are several ways of adjusting damper travel, or stroke, and some of the ways will now be considered.

Close to the damper motor you will see an adjustable socket, or in some cases a clevis, that can be screwed in or out to extend the damper shaft or shorten it. This adjustment usually has a "check" nut to lock it in position after it is adjusted - this is one adjustment. The shaft rod, or extension shaft, may be bolted to a ball joint on the other end and the rod may be slipped inside the ball joint to the proper adjustment. Then again, we have the slotted crank arm that can allow the ball joint to be slid up or down until the proper travel is accomplished. The sketches may help:



Pilot positioners or relays are sometimes used to position dampers by limiting the stroke or starting the travel at certain points. In the coming section under "RELAYS" we will see how these are used to control damper operation and sequencing of dampers.

IT IS NOW TIME TO SEE THE TAPED DEMONSTRATIONS AND DISPLAYS ON TAPE #2-B. IF YOU DO THIS, IT WILL HELP GREATLY WHEN YOU TAKE THE FOLLOWING WRITTEN REVIEW.

Note: Please do not take this written review until after you have viewed Tape #2-B.

1. Name as many places as you remember where "Damper Motors" are used in air conditioning systems?

____

____

____

____

2. Are OSA dampers usually Normally Open (N.O.) or Normally Closed (N.C.)?

____

3. If you wanted an OSA damper to open fully when the blower fan starts, what device would you use to accomplish this?

____

4. Are return air dampers usually N.O. or N.C.?

____

5. What does a "Face and By-pass" damper do?

____

6. What do "Mixing" dampers do?

____

7. Why are "Static" dampers necessary in a double duct or extended plenum system?

____

____

8. What are the basic parts of a Piston Damper Motor (P.D.M.)?

____________________ ____________________

____________________ ____________________

9. How would you check the diaphram in a P.D.M. without taking the motor apart?

____

10. What determines when a P.D.M. shaft starts moving and when it stops moving?

____

11. What does it mean when we say that OSA, Return and Exhaust damper motors are "matched"?

____

12. How would you explain what it means to "Sequence" damper operation?

____

13. A damper that travels from full-closed to full-open travels how many degrees?

____

14. If you have a "Crank Arm" that is not adjustable and is being driven by a number 4 P.D.M., what number crank arm should be used?

____

15. The "Slotted" crank arm can be used to change the travel of a damper, so what effect would be accomplished by moving the "Ball Joint" from close to the damper shaft end to the outer end of the crank arm?

____

16. How would you know when you have a good adjustment of P.D.M. linkage to a damper?

____

LETS GO ON TO THE NEXT SECTION #3-A

Pneumatic valves, in use in pneumatic control systems, have two parts. 1) a valve "body", and 2) an operator. As you will observe, the principle of pneumatics is used here, that is, air pressure overcoming spring pressure to open or close the valve.

Among the types of valves used are two-way (or two openings - one in and one out). This valve may be straight-through or angle type. The three-way valve has three openings - two ins and one out, or one in and two outs.

Terms that apply to valves are Normally Open (N.O.) and Normally Closed (N.C.) You recall, the definition of N.O. is "open" with no air on the operator and N.C. is "closed" with no air pressure to the pneumatic operator.

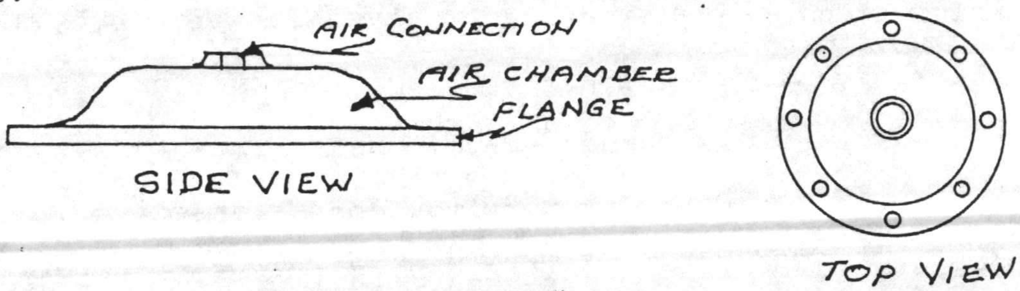
Valves have capacity ratings known as Gallons per Minute (G.P.M.) and "Cv" factor. The design engineers, that designed the control system, have "sized" the valves for proper flow, so don't be concerned if you see a valve that has smaller fittings than the pipe size it is connected to. Many times this is done, but the valve still has the proper flow characteristics. When it is necessary to replace a valve body, the same Cv rating should be used. Usually the original control drawing or specification sheets give this information. If not on this drawing, it may be found in the "M" (mechanical) section of the original drawings that have a listing of valves under "Air Conditioning".

The Cv ratings cover a tremendous range; for example, one manufacturer lists Cv ratings from .2 to 1000 which means that valves are available that will pass a large volume of water at different in and out pressures.

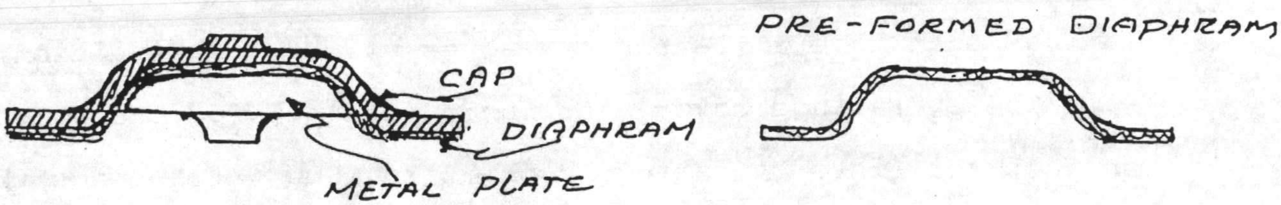
Before we get into valve "bodies", to discuss seats, discs, plugs, etc., lets consider the valve "Operator" or as some say, 'Actuator". This is the part that powers the valve to move the valve stem in and out of the valve body.

Here again, the control design engineer has matched the valve top or operator to the valve body as to flow characteristics required. One valve body may receive a great variety of operators to handle different water pressures and flow. The operators also should be listed on the control drawing or "spec" sheets.

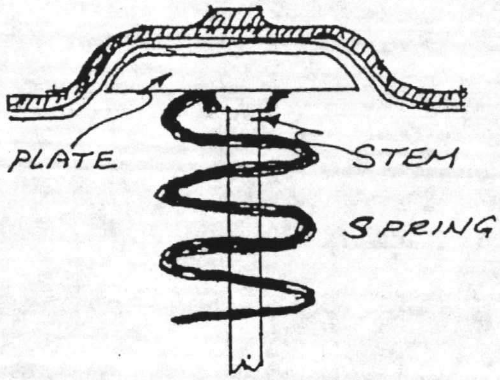
Starting at the top, or diaphram end of the operator, we find the cap or top that is the pressure chamber for the control air and enclosure for the diaphram. This cap has a tapped female pipe threat connection to receive the control air. It may look like this:



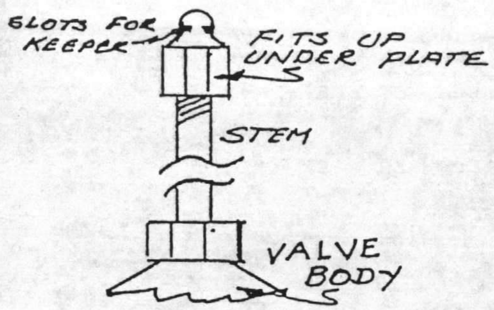
Inside this cap we find a "moulded diaphram" that has been pre-formed to fit the contour of the cap and to move just the right amount of travel. We now show this diaphram under the cap:

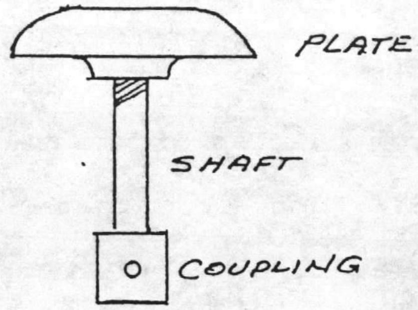


Next we find a metal plate under the diaphram that the diaphram pushes against to provide a large surface to transfer the motion to the valve stem that is fastened under the plate. Thus:

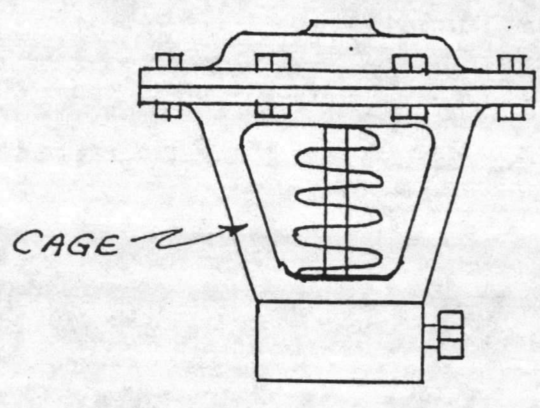


This metal plate also serves as a top retainer for the spring that returns the valve stem when the control air is removed from the top cap. The shaft or stem may be the stem that goes inside the valve body or it may couple onto the actual valve stem. In any event, it is attached to the underpart of the plate:





The above sketch shows the spring in place under the plate and just about all that is left to the operator is the cage that all these parts are enclosed in. The cage of the operator is the frame that holds the valve top together and seals the diaphram pressure tight. It makes the operator one unit. This is how a valve top may look:



There are several designs of valve tops by various valve manufacturers but the sketches will give you a good idea of how they go together. The video tape will break down some valve tops and bodies. About the only thing that goes wrong with a valve top besides corrosion and breakage is a leaking diaphram. This diaphram can dry out and become porous after being in service for a long time. Operators used on steam and hot water valves usually have a shorter diaphram life than valves used for cold water.

To check for a bad diaphram, first set the controller for full output and if you find that you do not have full air pressure on the branch, or leaving port of the controller, the diaphram may be leaking. With full air on the valve top, listen for the leak if it is not in a location that is too noisy. To make sure that the leak is not between the controller and the valve, remove the tubing from the top of the valve and hook up your squeeze bulb to the valve. Pump air into the valve operator and if it holds air, the diaphram is o.k. If not, replace the diaphram and check again. Diaphrams for valves can be checked without removing the valve from the system.

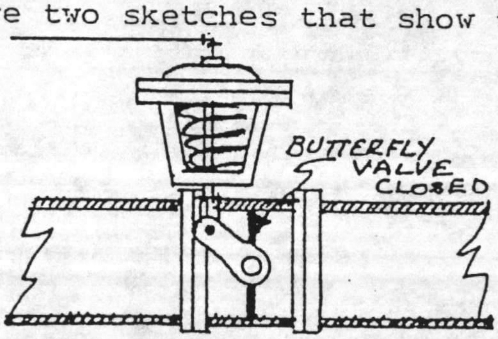
Now, lets consider the valve "body". The various parts of the valve body are, 1) the casting, which is machined to receive the seat, the threaded fittings and the packing chamber; 2) the valve stem, usually made of monel or stainless steel to resist corrosion; 3) the disc, usually a composition material that is fastened to the stem; and 4) the packing, or seal, around the valve stem.

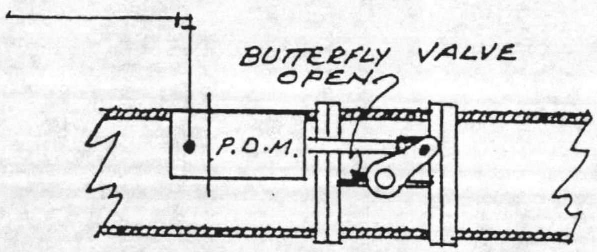
Larger valve bodies may be machined from cast iron, malleable iron or steel. These usually have flanged connections instead of threaded connections and bolt to other flanges in the piping with a gasket between the flanges.

The smaller valves are usually made of brass or bronze and have threaded connections to connect to the piping. Regardless of the type and material used in making the valve, the purpose is to control the flow of either steam or liquid used in the coils of air conditioning systems.

Probably the first valve we should mention is the "butterfly" valve. This is a simple round disc inside of a piece of pipe or ring that opens to allow flow and closes to stop flow. This type of valve is used mainly in larger water lines that carry a lot of water, such as cooling towers, evaporative condensers, etc.

Operators of different types have been used to drive the butterfly valve. They may be regular valve operators or motors like the P.D.M.s that we have discussed under damper operators. Here are two sketches that show these:

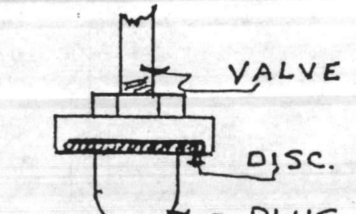


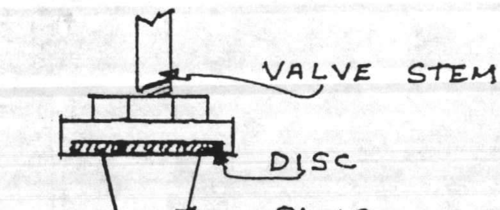


There is what may be termed a "packing gland" around the shaft that is used to drive the valve. This prevents leakage around the shaft as a seal. About the only service needed on this valve is to make sure that the operator moves it through the complete stroke and that the shaft packing does not leak. It is a full 90 degrees travel from closed to open. If it is necessary to check the operation of this valve, we recommend it be done without water flowing through the pipe line. The reason for this is that this valve could slam shut and has been known to break the disc from water pressure. When you determine that it operates freely, link it back up to the operator before turning on the water pump again.

Steam valves may be similar to water valves but the material used for the plug or disc is usually different. They require a high temperature material to stand, not only the temperature but the cutting action that steam has when flowing rapidly can cause what is called "wire draw" or grooves across the seat and disc.

If close control is needed with a minimum of temperature difference, a valve stem may have what is called a "plug" instead of a disc. A plug allows the valve opening to increase very gradually making it easy to prevent "override" of temperature. The shape of some plugs are as follows:

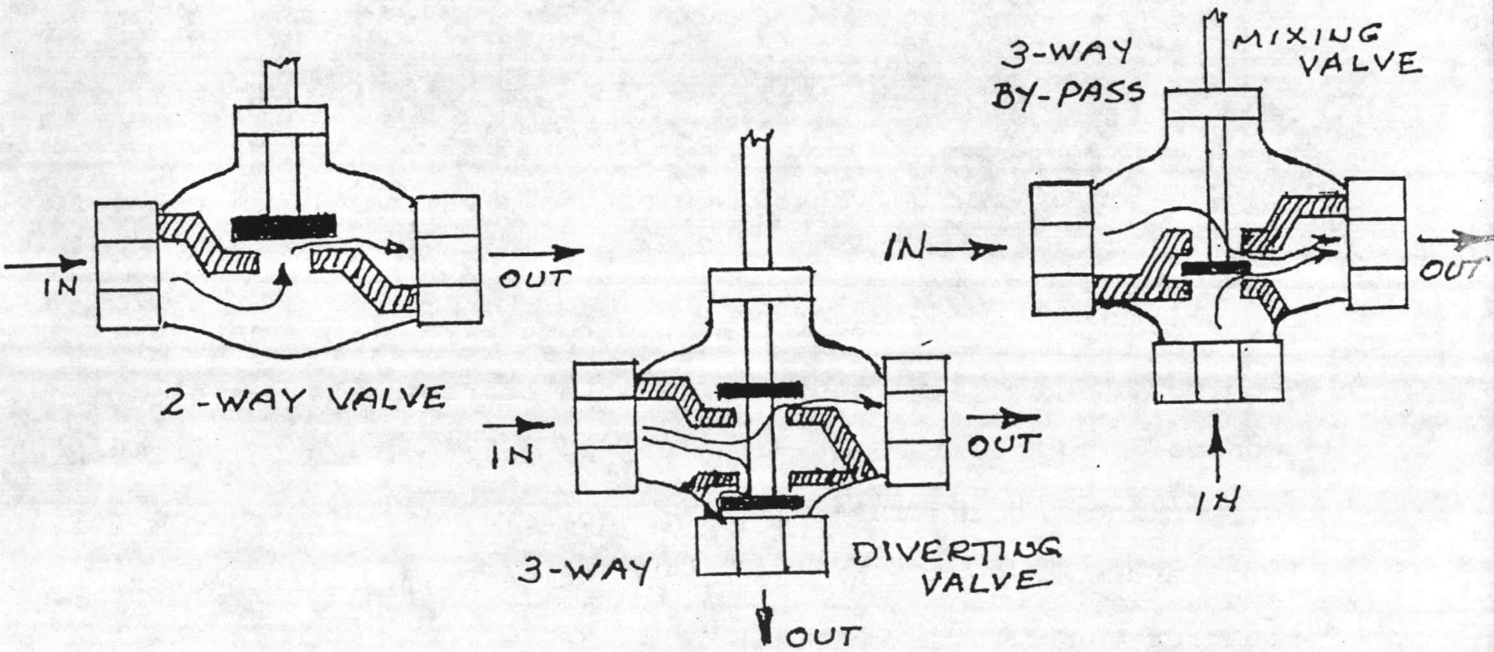




The actual shut-off is when the disc is against the seat. As you can see, when the plug backs up away from the seat, the opening is very gradual.

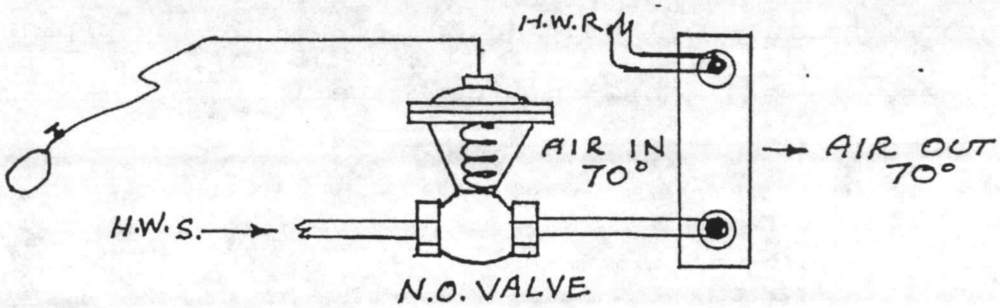
In many smaller, less expensive valves, the seats are machined with the valve body. In others, the seats are removable and can be replaced. On valve bodies there is a flow direction arrow to indicate the in and out. On two-way valves, if ever in doubt as to the right direction of flow, always pipe the "in" water so that the flow is against the bottom of the disc and it closes against the flow. If it is piped backwards, it may slam shut when the disc comes close to the seat. It could cause what is called "water hammer" or "chatter".

Three-way valves have arrows that point from the inlets to the outlets. There are two types of three-way valves, 1) the "by-pass" valve which has two inlets and one outlet, and 2) the "diverting" valve that has one inlet and two outlets. The sketches will show the internal seating and also show the piping direction of these valves. More on video tape:



The different control companies have different symbols or markings on their valve bodies to designate the in and out directions. On three-way valves, some say, in-in-out, others say 1-2-C (C for common or outlet), still others have U (upper port), B (lower port), C (common). Also some say A-B-AB. It is especially important to observe these symbols before removing a valve from the piping. Most control drawings indicate the proper connection.

To test a pneumatic valve for positive shut-off, simply pump full air pressure of the spring range, plus 2psi over the spring maximum range, and feel the coil or piping that the valve feeds. Of course, conduction will carry heat or cold for a short distance but the in and out temperature of the air through the coil should be the same if the valve is "seating" and holding properly. Another sketch:

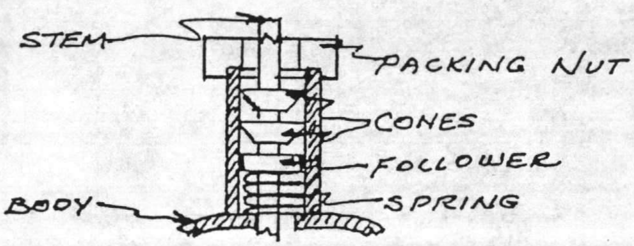


With a N.C. valve you would check with no air on the valve top.

The method of sealing around the valve stem, that moves in and out of the valve body varies with different valves also. Most control companies sell packing "kits" that contain the right kind of packing and the lubricant for their valves. If you are using "split rings" that slip around the valve stem, it is necessary to stagger the cuts or splits to prevent leaking through the cuts. There are types of grease or lubricants used with valve packings that have a wide temperature range or rating -- some from -40 to 450 degrees F.

Some other packings are Teflon rings and graphite-impregnated ropes and packing rings.

Always replace packings with the same type as the original. When installing the cone-shaped rings, it is necessary to put the rings right-side-up or there will be no seal between the packing and the valve stem. For example, one control company makes a packing that is a teflon ring that is a solid cone with a hole for the shaft. In this type of packing, there is a spring and follower on top of the spring that keeps a tension on the packing rings to automatically take up the wear and keep the packing tight against the stem. The spring and follower pushes against the high part of the cone so that the constant pressure that is exerted by the spring tends to close the hole that the stem passes through and thereby keeps the packing tight around the stem. Thus:

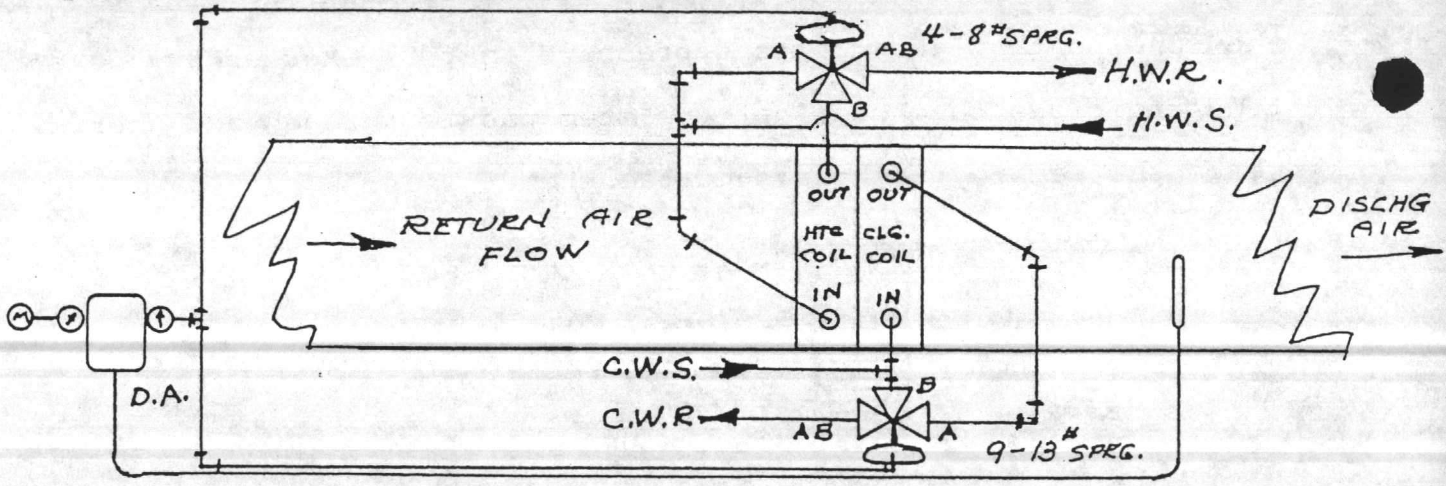


Always lubricate the packing when installing it, with the proper grease. It is usually packed with the packing kits. Before repacking a valve, always inspect the stem to be sure it is not pitted or corroded. If it is, replace it. When you clean a valve stem, use a mild solvent first and then if necessary a fine abrasive crocus cloth can be used to polish the stem. Never use a coarse emery or sandpaper.

Any packing that does not have an automatic tightening system, be very careful to not over-tighten. Usually just beyond finger-tight is enough.

One special caution! When repairing larger valves, be very careful as you remove the operator and spring! Some of these springs are under tremendous pressure and require a special repair kit, or jig, to release the spring very gradually before removing the spring retainers.

Pneumatic valves may be "sequenced" or "stepped" to control water to the heating and cooling coils. This is done in the same way as we did with P.D.M.s for damper operation -- by spring ranges. Lets illustrate an example of a Hot and Cold water coil system to a single discharge duct, or plenum:



If we follow this sequencing through the diagram, we can see how the cycle works to control flow to the coils in turn or sequence. For now, forget the cooling side and look only at the heating side of the system. Notice that the Hot Water Supply (H.W.S.) is teed into the "A" port of the valve and the "in" connection on the coil. The "out" connection of the coil goes to the "B" port of the valve and the "AB" port of the valve goes to the Hot Water Return (H.W.R.). Our three-way valve is N.O. from the "B" port to the "AB" port. This means that with no air to the valve operator the hot water will flow from H.W.S. into the coil and through the coil, heating the coil, and out of the coil to port B, through the valve and out port AB to H.W.R. We are now on full heating.

As the discharge air warms up, in our discharge plenum, the discharge controller senses the change and because it is a Direct Acting (D.A.) control, the output or branch pressure starts to increase as the temperature in the discharge plenum increases. When the temp. rises to the point that we have 8psi output from the controller, the heating valve closes off port B of the valve and now the valve is full open from port A to port AB thus putting the valve on by-pass. This means that no more hot water is going through the coil because it is all being by-passed around the coil. At 8psi the cold water valve is also on by-pass because it does not start to open to the coil until 9psi is put on to it by the controller. We have what is called a one psi "Dead Band" which means that from 8 to 9psi we are neither heating or cooling -- they are both on by-pass.

Now, the space has warmed up so that the return air temp. goes on above the desired discharge air temp. needed. It is necessary that we now add some cooling to the space. The heating valve stays on by-pass and the cooling valve starts to open. If a full demand for cooling is needed, the discharge air controller will open the cooling valve to let the cold water flow through the cooling coil to cool the discharge temperature. At 9psi the cooling valve starts to open and at 13psi it is full open to the coil and cold water is flowing from C.W.S. through the coil, out to port B of the valve, through the valve, out port AB and into the C.W.R. Port A is closed and we are on full cooling.

This sequence allows only one coil to function at a time so we are not heating and cooling both at the same time.

Do not let the valve piping confuse you. Take it in segments, one coil at a time, and when you understand how the one works, go to the next one and eventually you will be able to put the whole picture together. The place to start is to observe the action of the controller, (either D.A. or R.A.) then follow the water flow from supply, through the coil, to return. We recommend to make your own sketch of the piping one segment at a time and study it. If you do this, the mystery will disappear.

It is now time to see the taped demonstrations and displays on TAPE #3-A. If you do this it will help greatly when you take the following written review.

Note: Please do not take written review until after you have viewed Tape #3-A.

1. What are the two main parts of a pneumatic valve?

_______________ and _______________

2. How do you tell the difference between a two-way and a three-way valve?

____

3. Explain what is meant by a:

N.O. valve _______________

N.C. valve _______________

4. When replacing a defective valve, what "rating" should you look for?

The _______________ Factor.

5. If you suspect that the diaphram in a valve operator is leaking, how would you check it?

____

6. In our sketches, we progressively built a valve top and we determined what usually failed or went wrong with this operator. Do you recall the main problem?

____

7. What is a "Butterfly" valve?

____

8. When would a valve with a "Plug" be preferred over one with a "Disc"?

____

9. If no arrow indicating flow can be found on a two-way valve body, how would you know which is "in" and which is "out"?

____

10. What is the difference between a 3-way By-pass valve and a three-way diverting valve?

    The By-pass valve has ______________________________

    Diverting valve ______________________________

11. What is especially important to look for or observe before removing a three-way valve from a water system?

    ____

12. How do you test, or check, a pneumatic valve for positive shut-off before removing it from the lines?

    ____

13. When you are repacking a valve, what type packing would you use?

    ____

14. Why would you not use just any grease to lubricate packing or packing rings?

    ____

15. Explain what it means to "sequence" two valves?

    ____

16. Do you recall what valve "By-pass" or "Dead band" using 2-3 way valves means?

    ____

17. Water piping can be confusing when we are trying to figure out the way they are piped into the system. What will help us to understand the reason why they are piped a certain way?

    ____

    ____

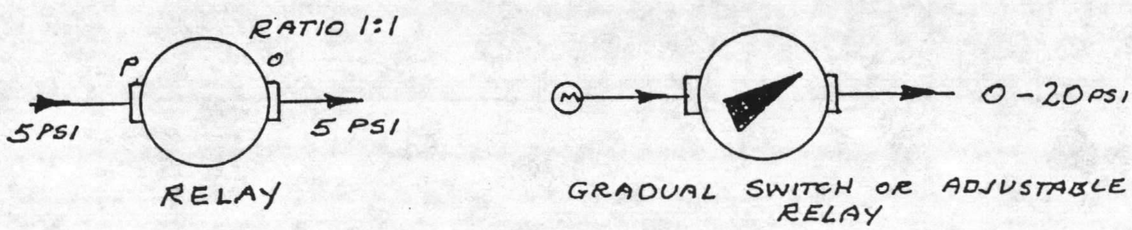
LETS GO ON TO THE NEXT SECTION #3-B.

The word "Relay" literally means "To Send Onward". In pneumatic control work, this is exactly what this device called a "relay" does; it receives a signal into it, called a "Pilot Signal", and sends it on to an "Output" signal.

Relays are fascinating devices, not only because of how they operate, but also the many different designs-functions. The old saying, "You Never Get Something for Nothing" really applies to pneumatic relays. For example, it is not possible to put a 5psi signal only into a relay and get a 10psi signal out...unless, of course, you add a (M) air supply that is over 10psi. Although many relays operate without a (M) air supply, of say 20psi, you can still have the highest output equal to the highest input of a relay. If this does not confuse you, it is a miracle -- not to worry.

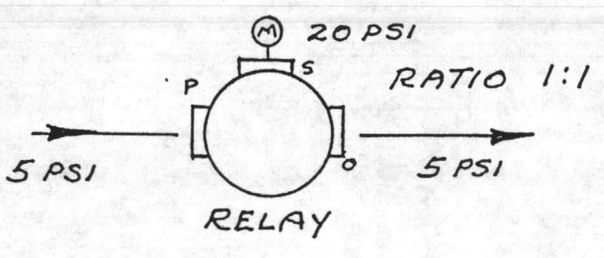
We are going to start with very basic operation of relays and build to the point that we feel you will be quite comfortable with them.

If we have a pneumatic relay that receives a 5psi signal in (the port marked P) and a 5psi signal out (the port marked O) we have what is called a 1 to 1 "Ratio Relay". It may be noted as 1:1 on a drawing. We will illustrate this along with an adjustable relay called a "Gradual Switch".



More explanation on the 1:1 relay, but first lets clear up a term that is sometimes used to designate a relay. That term is "Cumulator" and is just another name for relay. This word, cumulator, is actually the word "Accumulator" with the "Ac" or first two letters dropped. To accumulate means to collect or to gather together and that is just what a "Cumulator" does, it gathers inputs to direct them to outputs.

Back to our sketch: the "A" sketch shows a 1:1 relay with a 5psi in and a 5psi out. When would you ever want this condition? Only if you want to convert a "Weak" 5psi signal to a "Strong" 5psi signal. Lets say that you have a damper motor with a large diaphram to fill up with air, and a controller that puts out a weak signal of very little volume. It would take a long time to fill up the damper motor chamber from this weak signal, so lets put a 1:1 relay in the line and see what happens. If we add Ⓜ air to our relay, we can give the signal a boost and still use the 1:1 feature of the relay. Now, instead of filling the large diaphram of the P.D.M., we put the signal from the controller into the very small diaphram of the relay and pass Ⓜ air on to the large diaphram of the P.D.M. so it will operate faster and more positive from the now strong signal. The relay would now look like this:



There are a great variety of ratio relays also. You can have a 5psi in and a 10psi out; after adding (M) air, you now have a 2:1 Ratio Relay. This type of ratio relay is very popular because it can be made adjustable and used where you want a controller to reach a certain output pressure before starting to move a damper or actuate a valve or close a P.E. switch.

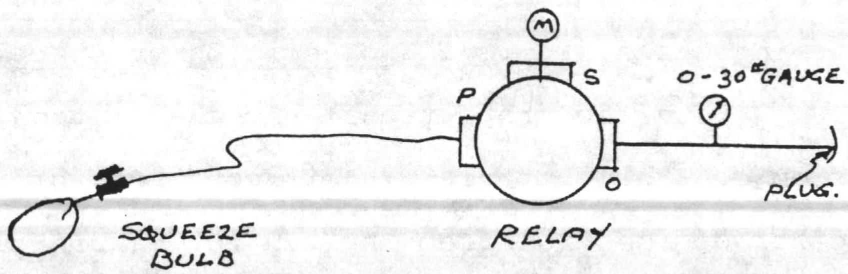
The four terms used in designating relay action are: 1) Direct Acting, 2) Reverse Acting, 3) Proportional, and 4) 2 Position or Snap Acting. Direct Acting simply means, an increase in pilot pressure causes an increase in output pressure. Reverse Acting, of course, means an increase in pilot pressure causes a decrease in output pressure. If the output pressure increases gradually, when the input, or pilot pressure increases, the relay is Proportional or Modulating. When the output pressure goes from 0psi to full 20psi or (M) air pressure, when the pilot pressure is increased, it is a Two Position or Snap Acting or Positive.

Both the proportional and snap acting relays are available from control companies in either direct or reverse acting. Another designation from the control manufacturers is "Class 1" (for direct acting) and "Class 2" (for reverse acting).

If you do not already have bulletins on the type of relays in your control system, we strongly recommend that you get them from the control company. Most companies have "Pull-out sheets" of every piece of control equipment that they install, and these are usually available on request. If possible, get "Service Bulletins", but if not, the "Product Bulletins" will be of great help to you. Look on the control drawing and make a list of devices you want information on. Most control contractors leave, with the Maintenance Engineer or the Building Manager, a book that has control drawings and product bulletins all bound together. We will discuss the operation of the various relays, but any information you can get will be an aid in trouble-shooting your system.

If you can obtain "Service line", "Product line" or "Counter line" parts and equipment catalogs from the control company, it will list what repair "kits" are available for their relays and other devices. Some sell kits that contain filters, springs, diaphrams, etc., the parts usually necessary to repair a relay that is possible to repair.

It is easy to check a relay for proper operation by disconnecting the pilot line "P" and using the squeeze bulb to provide the pilot pressure and watch the output pressure for what happens when you pump the pilot signal. A sketch:

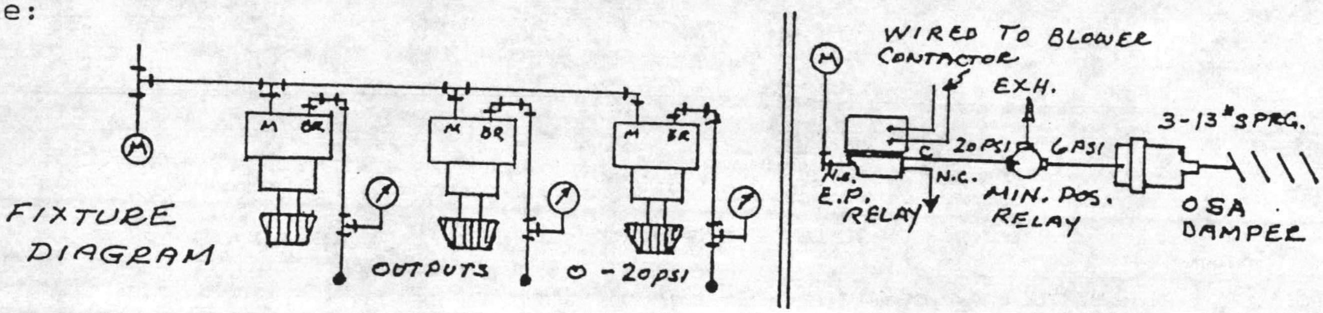


If you wish to check a relay with two or more inputs, and you have enough of these, we recommend that you make up a fixture that will be very useful. The one we are using in the taped demonstrations is made from three old gradual switches and three gauges. This fixture can be useful in setting up controllers with many inputs, checking P.E. switches, checking spring ranges and diaphrams, P.D.M.s, valves, relays, etc. It really is a "poor man's" simulator but works great.

Control companies sell "Suitcases", "Simulators" etc., but this little "goodie" can be made cheaply and save a lot of bucks. Make it portable -- build it into a small box or "bread board" it so you can take it out to the equipment rooms for use in control panels. Just "tee" into the (M) air line in the panel and you can set up any condition you wish. The parts you need for this fixture are available from your control company.

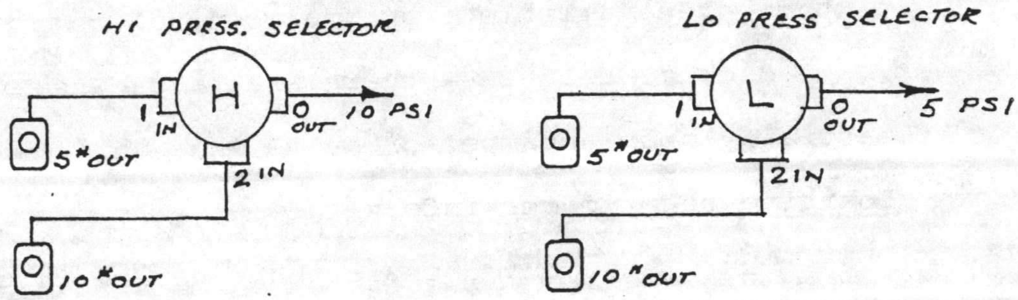
Back to relays -- there are times when you may need to just partially open a damper or valve, and this is where the Minimum Position relay comes into play.

There are many uses for this device, but one good use might be to provide a minimum opening of an OSA damper when the blower starts. Regardless of the demand from the OSA damper controls, (even if they are calling for a closed OSA damper) you would like to have a OSA damper taking in some OSA, here is how it can be done:

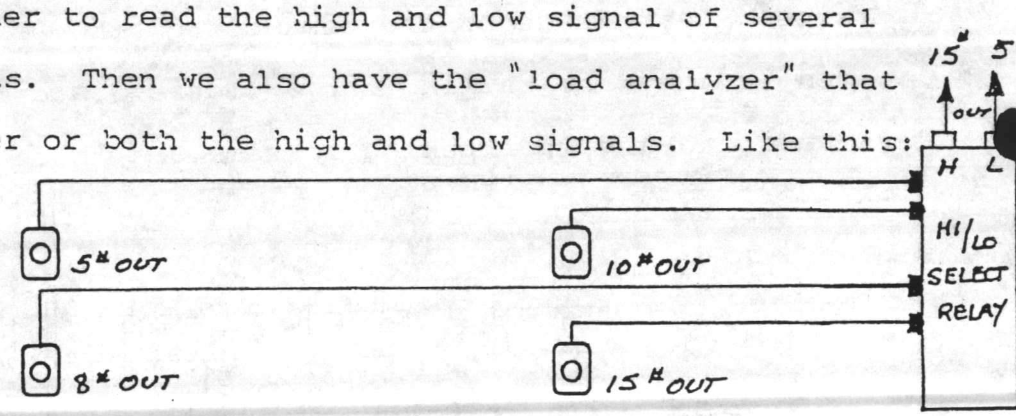


The E.P. Relay, or (E.P. Valve), opens the (M) to the "P" or input of the "Minimum Position" relay, which allows only 6psi to go to the OSA minimum damper motor and opens the damper to a pre-set amount of, say, 15 to 20%. When the blower stops, the (M) air is exhausted from the E.P. relay and when it falls below 6psi the damper closes, sealing off the OSA.

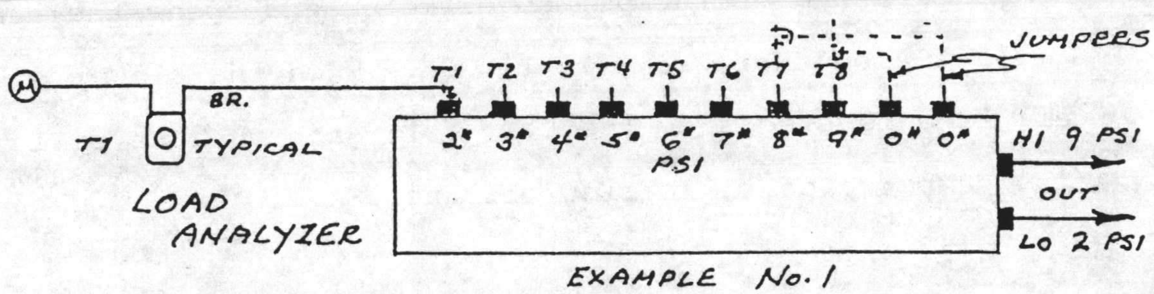
Another interesting relay is the Hi/Lo Selector relay, or as one company calls it, the "Load Analyzer" relay. This relay receives the signals of several (T) stats and selects the highest and/or lowest signal to be used in the primary control of equipment. If you have a high or a low pressure selector relay, this is how they would work:



Some manufacturers have a combination of selectors that can be plugged together to read the high and low signal of several zones or (T) stats. Then we also have the "load analyzer" that will select either or both the high and low signals. Like this:

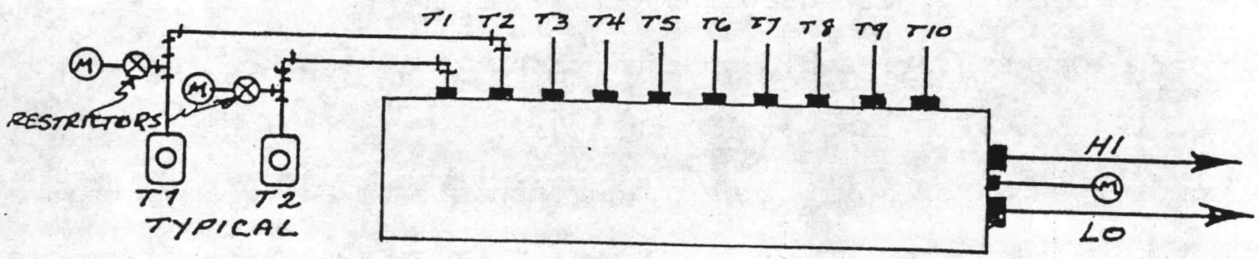


These selectors are made to receive up to as many as ten signals or may be "ganged" or plugged together to receive nearly any amount of inputs. Thus:

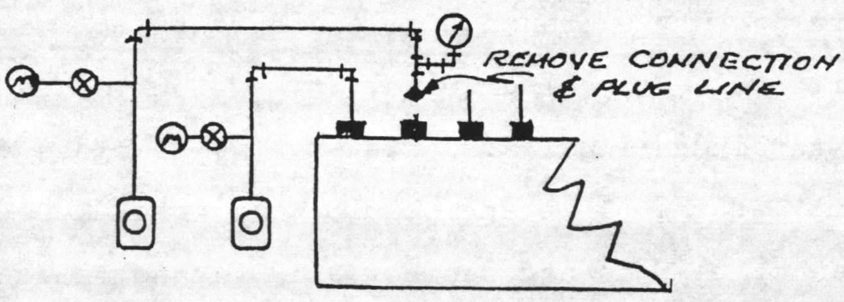


If you were using a 10 input selector that receives Hi/Lo signals, and had only 8 (T) stats tied into it, it would be necessary to "jumper" the not used ports to one of the ports being used, because otherwise the "low output" connection would always have 0psi output, as in example No. 1.

Some of these selectors have (M) air tied into them and a bank of restrictors are used with 1 pipe room (T) stats. When this type of control is used, this is what you have:

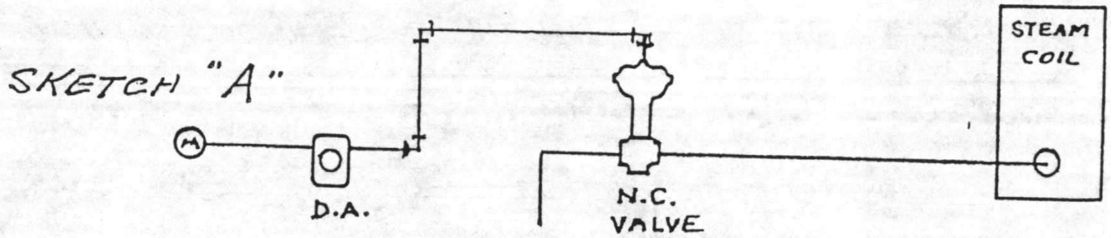


As you can see, in the examples, by using (M) air the full selection of the high and low signals is possible. The relay operation and also the thermostat output can be checked by removing the line as it enters the relay and plugging it. If there is not already a read-out gauge in the line from the (T) stat, you can tee in a gauge to this line and read the pressure from the (T) stat. Set the (T) stat for full output pressure and you should read full (M) air pressure on the gauge. If you do not read full (M) pressure, you may have a bad (T) stat, a leak in the line or a plugged restrictor. This is how the test can be used:

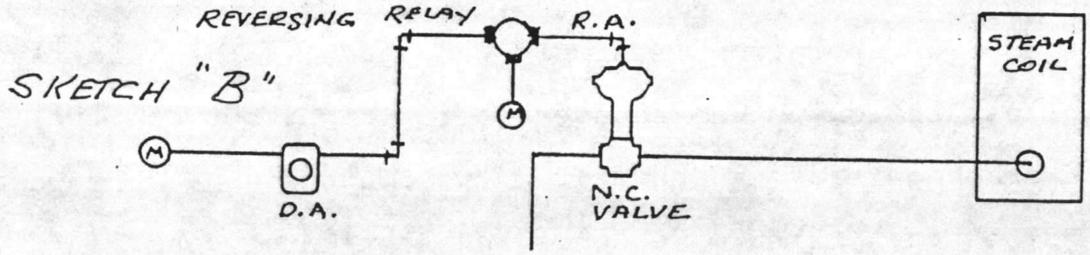


Lets move on to Cumulators. One control manufacturer still uses the term Cumulator to designate their great variety of relays. It is a good definition of a service that the relay performs as the definition will show. It is not difficult to understand what is meant by the word "Cumulator" if you go back to the original definition that they used to name the device. It really makes sense to say that the relay "accumulates" input signals and sends them on to where they are used to operate equipment. Lets take the word "accumulator" and drop the first two letters of the word, and we come out with the word "Cumulator". So it is a device that accumulates one or more signals and passes them on to an output signal. Dont get confused; they are really relays. There are some very ingenious cumulators. Some maintain a constant 9psi output when the inputs are in balance and vary their output when the inputs are out of balance. It is best to leave these to the "Apparatus Bulletins" to explain. If you have this type in your control system, be sure to get the literature on them before attempting to check their operation.

The Reversing Relay is truly a fascinating device, as used in pneumatic control systems, and are used in a great variety of places. For example, if you have a Direct Acting controller and you want to add a device that needs a reverse signal, why not stick a reversing relay in the branch line and operate it from the same controller? On a control drawing, it may look confusing to see a D.A. Ⓣ stat operating a N.C. steam valve to close down the heat as the temp. at the Ⓣ stat location increases. Lets look at why this cannot be done and see how a reversing relay will solve the problem. Sketch "A" shows the problem and sketch "B" shows the remedy using a reversing relay:



Sketch "A" would not work because, as the temp. at the (T) stat increases, the output increases and starts to open the N.C. valve. This means that the warmer the space becomes, the more steam pours into the coil. Now, lets see what would happen if we put a reversing relay between the (T) stat and the valve:



We can see from the following simple chart how the reversing relay changes its output with a change in input:

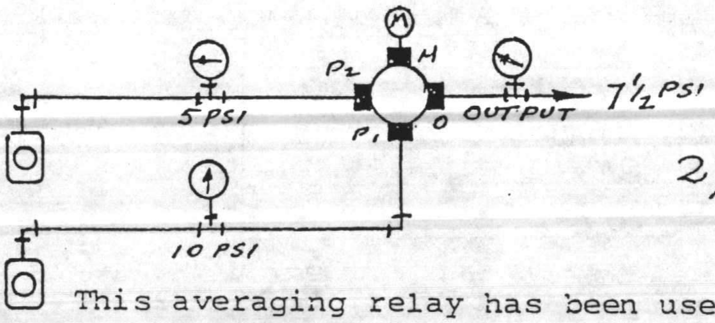
	REVERSING RELAY		
	INPUT		OUTPUT
#1	0 PSI	=	20 PSI
#2	10 PSI	=	10 PSI
#3	20 PSI	=	0 PSI

Notice that 10psi is the cross point, where both input and output pressures are equal. It is easy to figure exactly what the output should be, if you know the (M) air and input pressures. The key is that the output should always be found by subtracting the input pressure from the (M) air pressure. Using the above chart, lets see how this works out:

#1	#2	#3
Ⓜ = 20 PSI	Ⓜ = 20 PSI	Ⓜ = 20 PSI
− INPUT = 0 "	− INPUT = 10 "	− INPUT = 20 PSI
OUTPUT = 20 PSI	OUTPUT = 10 PSI	OUTPUT = 0 PSI

Some reversing relays, although factory-set to cross at 9 or 10psi, can be field-adjusted, after being installed, so they can be set plus or minus 9psi. So always consult the control drawing for this setting. Reversing relays can also be obtained in ratios other than 1:1. Just remember that the input and output pressures are the only ones that reverse, the Ⓜ air remains constant.

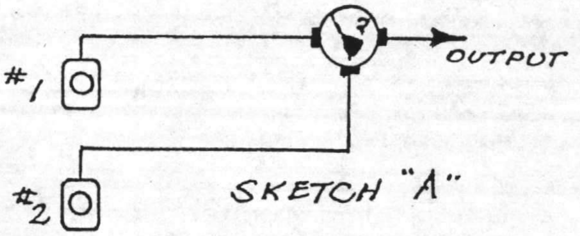
Another interesting relay is the <u>Averaging</u> type. Again, the theory of operation is simple, and just as the word "Average" implies, the output is an average, or right between two inputs. The averaging relay can have from two inputs on up to several inputs. Follow the pressure readings, on the sketch, and you will see how it works and why we arrive at the 7-1/2psi output pressure:

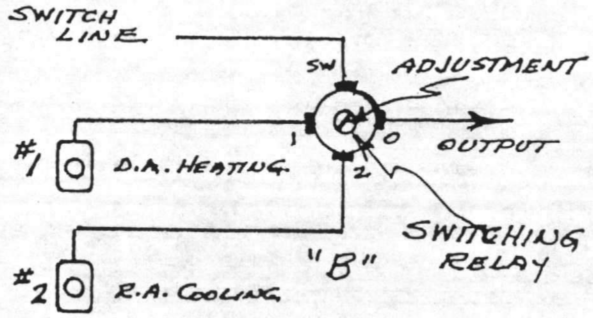


$$5 + 10 = 15\text{ PSI}; \quad 15\text{ PSI} \div 2 = 7\tfrac{1}{2}\text{ PSI}$$

This averaging relay has been used when there are two or more room Ⓣ stats in one large room. It will call for an average condition in the space. Of course, it can also be used to average Ⓗ stats in a space.

Still another type is the <u>Switching</u> type relay. This device is used to "switch" one or more inputs to an output. If you had a "Manual" air switch, it would look like this:





In sketch "A" you would have to manually turn the knob from (T) stat #1 to (T) stat #2 to switch the signals to the output. This can be done automatically by using a pneumatic signal into the relay to do the switching, as you can see in sketch "B."

Usually, an automatic "switching" relay is adjustable so that the "switchover" point can be changed in the field. Sketch "B" also shows how the switching relay can be used to change the output from the heating (D.A.) (T) stat to the cooling (R.A.) (T) stat.

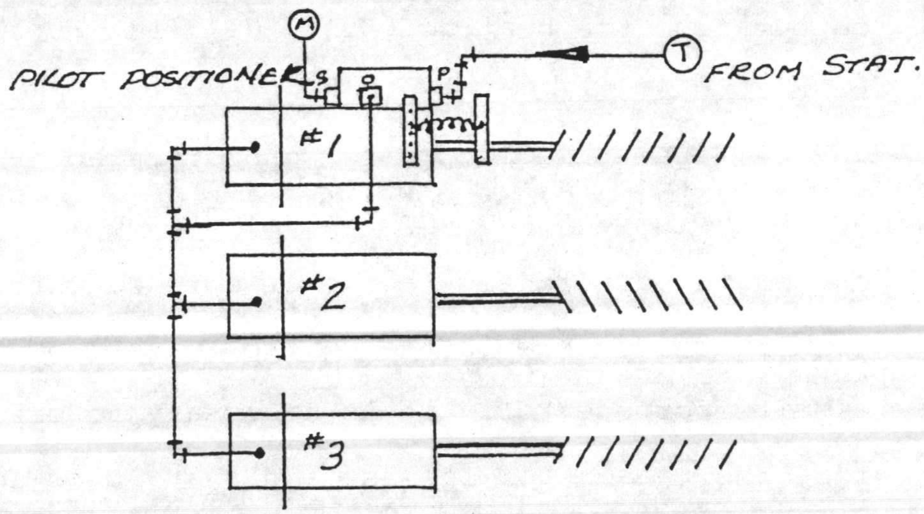
There are some pretty sophisticated switching relays, but the principle is the same in all of them, namely, to switch two or more input signals to one or more outputs.

When you see in the control panel, or on the control drawing, a <u>Multi-purpose</u> relay it is necessary to carefully study and analyze the reason for its use and what it is accomplishing. The way it is piped into the system will help to determine its use. Some of the things this single relay may do are:

1) Direct Acting (usually 1:1)
2) Reverse Acting (usually 1:1)
3) Minimum Pressure
4) Low Pressure Selector etc.

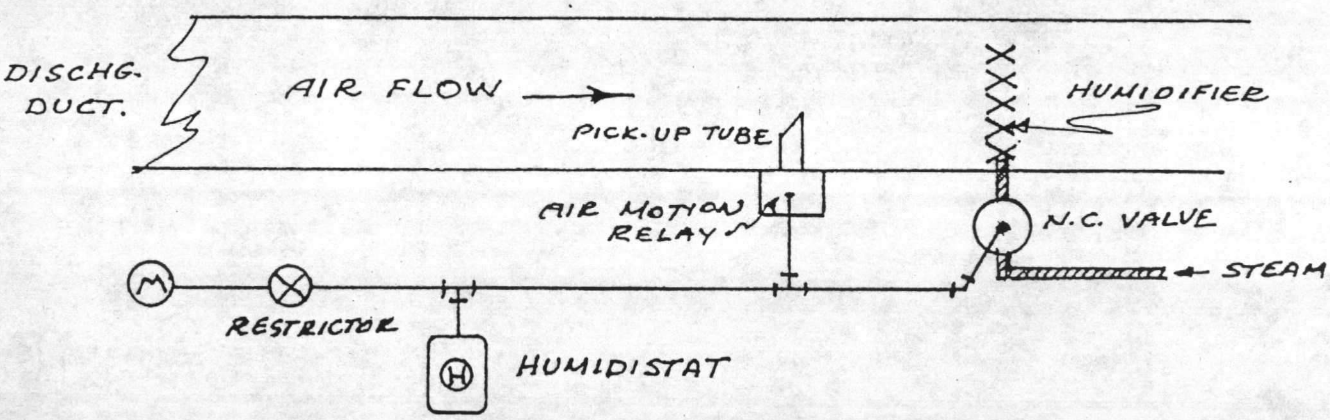
The (S) or (M) port is not always used for (M) air to this relay so the control drawing is very important in checking operation and purpose. It would be well to have a "Technical Instruction" or service bulletin on this relay before attempting to change the adjustment or set up a new relay. The adjustment serves different purposes, according to the piping connections.

<u>Pilot Positioning</u> relays also come in a variety of shapes and sizes but are mainly a power relay that can be adjusted in the field to receive a weak signal and put out a strong signal to a valve or damper motor. The adjustments include, 1) starting pressure and 2) span or range. One popular use of this relay is to power several damper motors, on large dampers, from a low output (T) stat. As shown:



A pilot positioning relay could be "cut-in" between P.D.M. #1 and P.D.M. #2 or #2 and #3, or any combination where more power is needed. They are very popular on Vane operators for refrigeration chillers and large valves. It is also advisable to consult the manufacturers recommendations for adjustments. Some have springs that change from one hole to another to set the "Range" point and screws or knobs to turn to set the "Starting point". All have (M) air to the relay, a pilot line in and an output connection.

There is a relay that is quite popular in conjunction with duct-mounted steam humidifiers. It is used to close the steam valve when the blower is not running. It also can be used to "trigger" a P.E. switch for starting and stopping air conditioning equipment. This is an Air Motion relay and the sketch shows how it can be used on a steam humidifier inside a duct:



The "Air Motion" relay, with no air flow in the duct, will bleed off all the air from the (H) stat to the steam valve and allow the steam valve to remain closed. When the blower is started, the "pick-up tube" of the air motion relay senses the air flow in the duct and closes the "bleed port" in the relay, allowing pressure from the (H) stat to take over control of the steam valve.

Without a control like this, steam would continue to flow into the humidifier and condense to water, possibly flooding the equipment room.

You can imagine just how impossible it would be to discuss every type and model relay in use today. However, from our discussions here and the tape demonstrations, we feel that this will help you to feel at ease with them. About the only repair to these devices would be to replace air line filters and clean them out, if they can be disassembled. There are some diaphram and spring kits available for some models.

IT IS NOW TIME TO SEE THE TAPED DEMONSTRATIONS AND DISPLAYS ON TAPE #3-B. IF YOU DO THIS IT WILL HELP GREATLY WHEN YOU TAKE THE FOLLOWING WRITTEN REVIEW.

NOTE: Please do not take this written review until after you have viewed Tape #3-B.

1. Explain why this pneumatic device is called a "Relay"?

____

2. When a 1psi change in input, or "Pilot" signal, causes a 1psi change in "Output", what is the "Ratio" rating of the relay?

______________________________ ratio

3. What needs to be added to a 1:1 ratio relay to make it useful?

____

4. Name the four terms used to designate relay action?

1) ____________________ 2) ____________________

3) ____________________ 4) ____________________

5. When the output increases gradually as the input pressure is increased, what action does the relay have?

____

6. When the output increases from 0psi to full (M) air pressure, on a slight increase in input pressure, it is called a

______________________________ relay.

7. State how you would use your "squeeze bulb" to check a relay for proper operation?

____

8. What would a "Minimum Position" relay be used for?

____

9. "Selector" relays can select, or choose, a signal and send it on to the output. If you have a selector relay receiving 5, 8, 10, and 15psi signals, and it is a Hi/Lo selector, what pressure will be coming out of the two ports?

H port pressure is ____________ L port pressure is ____________

10. If you have a 10 input selector and only 8 signals coming into it, what is usually necessary to make it work as a Hi/Lo selector?

____

Explain why this is so?

____

11. What is the "key" to finding the output of a "Reversing" relay?

____

12. Using this "key", if we have a 20psi (M) air and a 10psi input signal, what is the output pressure of a reversing relay?

____

13. Figure out the output pressure from an "Averaging" relay that has a 10psi signal into 1 port and a 5psi signal into the second port?

______________________________________ output pressure.

14. What does the "switch" line do to a "Switching" relay?

____

15. Why would it be best to check the control drawing before trying to adjust a "Multi-purpose" relay?

____

16. What is the purpose of a "Pilot Positioning" relay?

____

17. Explain the reason why an "Air Motion" relay would be used between a (H) stat and a humidifier valve?

____

18. What repairs can be made on relays?

____

LETS GO ON TO THE NEXT SECTION #4-A

Calibration can be quite an expensive word when it appears on a service bill. When the Chief Maintenance Engineer sees the bill marked "Calibrated Controls"...$250.00, he may wonder just what was done to his control system.

The word "calibrate" actually means "to bring everything into proper relation as respects "set point", "control point" and "operation"." So you can see, it really does involve a pretty technical operation; one not to be attempted by just any mechanic.

When you do receive your bill for calibrating your controls, you must realize that the serviceman sent out by the control company no doubt has many years of experience and training behind him. Because he represents the control company on the job, he has a great responsibility, not only to his company, but also to the customer. Many years of doing work for control companies helps us to appreciate what a specialized field control work really is.

For a maintenance mechanic to know how to handle control problems makes him a very valuable man to his employer. It is actually "job security" for a man to learn control systems and be able to "trouble-shoot" problems.

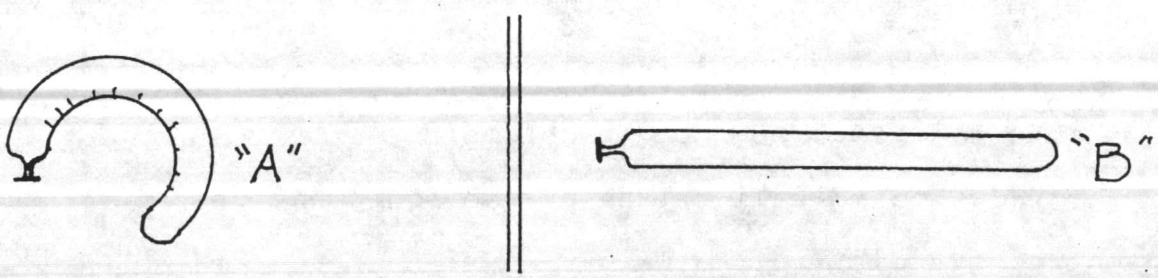
Now, on to calibration of the equipment used in pneumatic control systems.

Because pneumatic systems involve air pressure, it is necessary to have devices that measure or indicate air pressure. These devices are called "gauges". To "gauge" means "to determine the amount of force, or to measure". To do this accurately, they must be properly "calibrated".

We are going to start with the simple Pressure Gauge, as used to measure pressure, and explain how it works. Next we will see how we convert this pressure gauge to a temperature "read-out" gauge. It is our purpose to cover enough of the types of gauges so you will know how these work. From there we will progress to thermometers that can be calibrated to maintain their accuracy. Remote bulb thermostats and controllers will be covered and finally room thermostats and room humidistats.

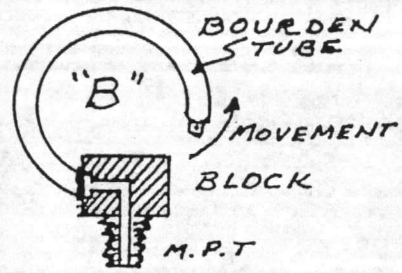
Most gauges used in pneumatic control applications use the "Bourdon Tube" principle. This is a hollow tube that is formed, or bent, into a near circle. It is made of thin enough material so that it can move and stretch slightly. One end of the circle is fixed or made solid and the other end is free to move.

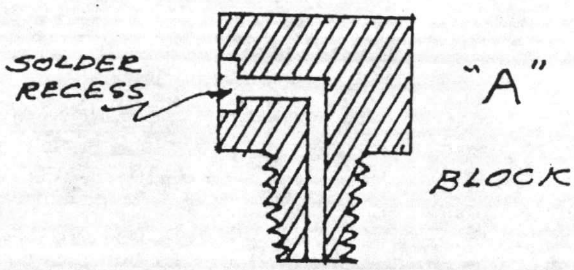
The principle of the Bourdon tube is easily explained by a simple balloon that a child may play with. If you blow a small amount of air into the balloon and shape it into a curve or circle, it would look like the "A" sketch:



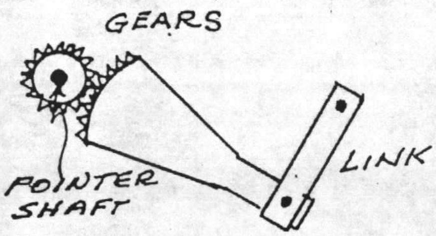
If you blow more air into the balloon, it will look like sketch "B". It has straightened out by an increase in air pressure. This, of course, is an exaggerated movement as compared to a Bourdon tube, but the idea is the same.

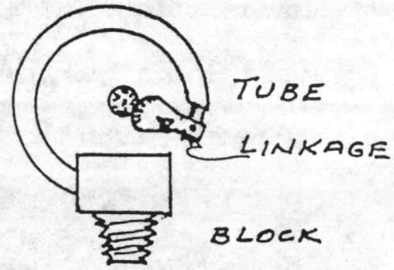
Now, we will build a gauge and see how it is used to measure pressure. First we have to start with a fitting that we can put the air through. This usually is a "male pipe thread" block (MPT). Sketch "A" shows the "fitting block" part of the gauge:



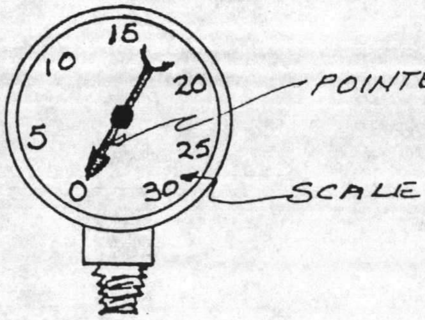


Sketch "B" shows one end of the Bourdon tube soldered to the block and the other end free to move as the pressure in the tube changes. If we hook up a link on the free end of the tube, we can use this motion to drive a gear that can move a pointer. Thus:





Adding a scale that reads "pounds per square inch" (Psi) and a pointer to the shaft, we have a pressure gauge. This pointer goes over a scale that indicates how much pressure we are measuring. The completed gauge looks like this:

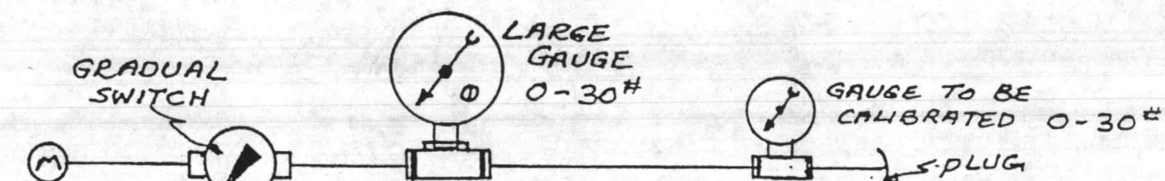


From the scale we see that we now have a 0 to 30Psi gauge that is used extensively in pneumatic control work. There are a number of ways to recalibrate pressure gauges. Some have "calibrating screws"; however, these are usually the more expensive ones because more gearing and levers are needed. This calibrating screw can be either on the face or the back of the gauge.

It is good to have one larger pressure gauge, 0 to 30psi, that is accurate to use as a standard in the shop, or portable, to check and recalibrate other gauges against. It is important to check the squeeze bulb gauge every three months or after you have dropped it on the floor a few times.

Another type of gauge can be recalibrated by holding the pointer firmly and turning either a screw or knurled knob on the pointer shaft. We used to carry a "Pointer Puller", that is made like a small gear puller, and used to pull off the pointer and re-set it to zero, with no pressure on the gauge. If there is no calibration feature built into a gauge, the only way is to remove the pointer and re-set it, being very careful not to bend the pointer or the pointer shaft.

A "gizmo" can be made from a very few parts to be used in calibrating pressure gauges. All you need is: 1) a large accurate gauge, and 2) a gradual switch. This is one way:

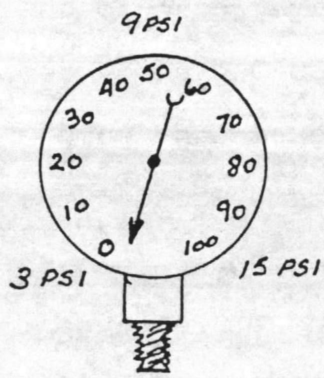


The large gauge can be built into a panel or a box, etc., and just a few fittings and a small amount of tubing will do the job.

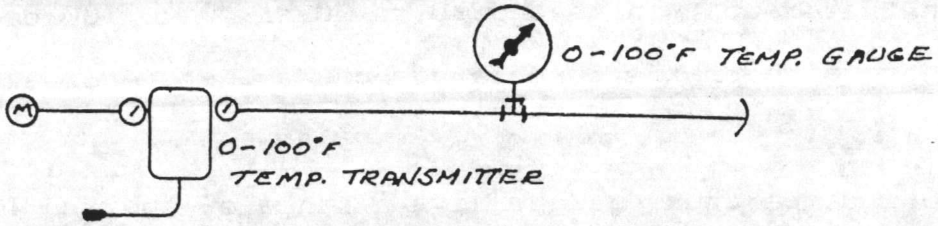
Pneumatic Temperature Read-out Gauges operate on the same principle as pressure read-out gauges. The only difference in many cases is the face scale. For example, lets take a 0 to 30Psi gauge and remove the pointer and scale plate. Now lets put a face plate on that reads, instead of 0 to 30Psi, 0 to 100 degrees F. We now have a pneumatic temperature gauge instead of a pressure gauge.

Most temperature gauges have a range of 3psi to 15psi to equal the scale used. (If you understand this, you are already a genius). However, bear with us and we will clear up the mystery.

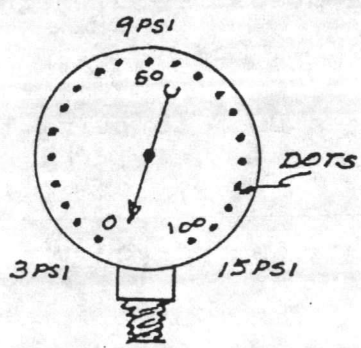
If you look at a temp. gauge of, say, 0 to 100 degrees F., and there is no air pressure to the gauge, you will see that the pointer reads well below the 0 mark on the scale. The reason for this is that it takes 3psi to bring the pointer up to the 0 mark, so 3psi = 0 degrees F. Now, lets put full (M) air pressure of 20psi on the temp. gauge and you will see that it goes beyond the 100 degree F. mark. The reason for this is that 15psi = 100 degrees F. This is the way a 0 to 100 degree F. temp. gauge scale would look with no air pressure on it:



To use this gauge to measure temperature, it is necessary to use a "Temperature Transmitter" or "Sensor" that has a "span" of 0 to 100 degrees F. so that the read-out gauge would match the instrument that is connected to it. Thus:



When you look at a temperature read-out gauge, take special notice of the scale span and also notice the "dots" that appear near the temp. readings on the scale. This is what we mean:



These dots are pressure indicators and are a great help in calibrating a temp. read-out gauge. Follow this procedure and see how this works. We are going to use our squeeze bulb to check and recalibrate a 0 to 100 degree F. temperature gauge. We connect a squeeze bulb to the gauge and pump 9psi on our squeeze bulb gauge. Next we look at the temp. read-out gauge and find that we have a reading of only 45 degrees F. At 9psi we should be reading 50 degrees F., so our temperature gauge is 5 degrees F. off. Holding the 9psi pressure on the temp. gauge, we remove the crystal, or transparent front, of the gauge and re-set the pointer to 50 degrees

F. at 9psi. We put the front back on the gauge and we have recalibrated the gauge. Simple!

This calibration procedure applies to all read-out gauges that have a 3 to 15psi range regardless of the scale reading. 9psi is half-way between 3 and 15psi so, if we pump 9psi into a 0 to 100 degree F. gauge, we should read 50 degrees F. If we pump 9psi into a 0 to 200 degree F. gauge, we should read 100 degrees F. If we pump 9psi into a gauge that reads -40 to 160 degrees F., we would have to read 60 degrees F. to be in calibration, etc. You will notice that some gauges are "bottom mount" and some are "back mount", according to how they screw into the fittings.

For Thermometers that have a remote bulb or "stab-in" types, all you do to calibrate these is to read the temperature at the bulb and re-set the dial pointer to match this temp.

Thermometer calibration is the very first place to start in the calibration of the pneumatic control system. These must be in calibration to come out with a good control set-up job.

There is nothing as valuable in control calibration as a "Master Standard Thermometer" that can be used to calibrate all other thermometers against. In the majority of control company shops that we have worked out of there has been such a standard. In the ones that do not have one, many problems have been experienced from trying to set up a system from inaccurate thermometers. In one shop there was a serviceman who carried two large dial thermometers that had labels on the face of them that read 6° high on one and 2° low on the other. These thermometers should have been discarded because they could not be recalibrated.

If you buy dial thermometers, either large or pocket type, look for the recalibration feature. It really is important.

Even digital thermometers have a calibrating potentiometer adjustment on the circuit board inside. These thermometers are usually very accurate and need no calibrating.

In the shop, mount a long glass thermometer on a board or panel that is free from vibration, and keep it as a standard to set the field service thermometers to and it will save all kinds of problems. The longer the thermometer, the better.

Now that we have accurate thermometers, pressure gauges and read-out temp. gauges throughout the whole control system, we can proceed to calibrate Controllers, and Remote Bulb Thermostats.

Every six months it is a good idea to correct and "tune up" all the controls and go through the entire system from Air Compressor to Room Stats. Between the six month recalibration work, you will be chasing "Spot" calls and "Emergency" service to keep the system going. The every six month complete check will save many of these emergencies.

The OSA economizer damper system may have two single input controllers to operate the dampers when the "OSA" and "Mixed" air conditions are reached. Step 1 is to consult the control drawing and see what the design conditions are for the economizer system. Building requirements, Ambient or outside temps., Air velocities, etc., all have a definite effect on design conditions, so lets use the control drawing whenever possible. There is usually a "Schedule" or note next to the damper controls that give us information. If there is a "Sequence of Operation", or an explanation of the control system, it will contain valuable information in calibration and set-up.

The OSA control for dampers, that senses OSA, is usually a Reverse Acting (R.A.) control and the Mixed air control is usually a Direct Acting (D.A.) control. These are used together in "Economizer" systems.

Step 1. Read the temperature of the OSA on the thermometer or temp. gauge.

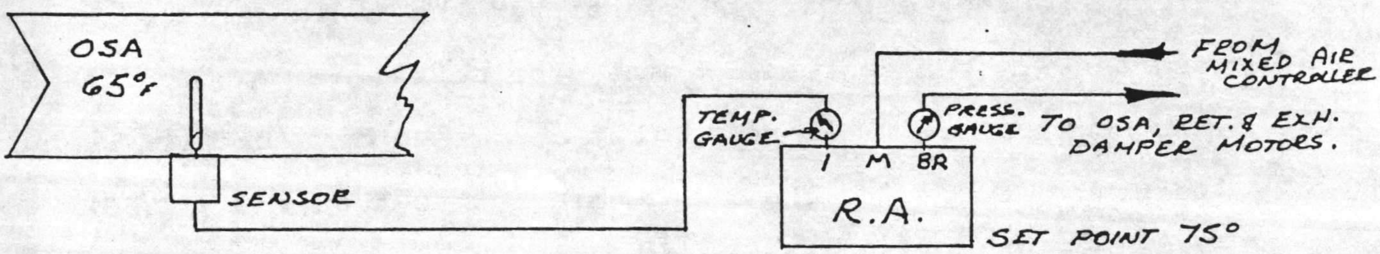
Step 2. Set the sensitivity of both OSA and Mixed air controllers at 2-1/2 to 5%.

Step 3. Turn the set-point dial, or knob, until 7 or 8psi is reading on the output or branch line gauge.

Step 4. Match the temp. read-out scale to the pointer that is above the scale.

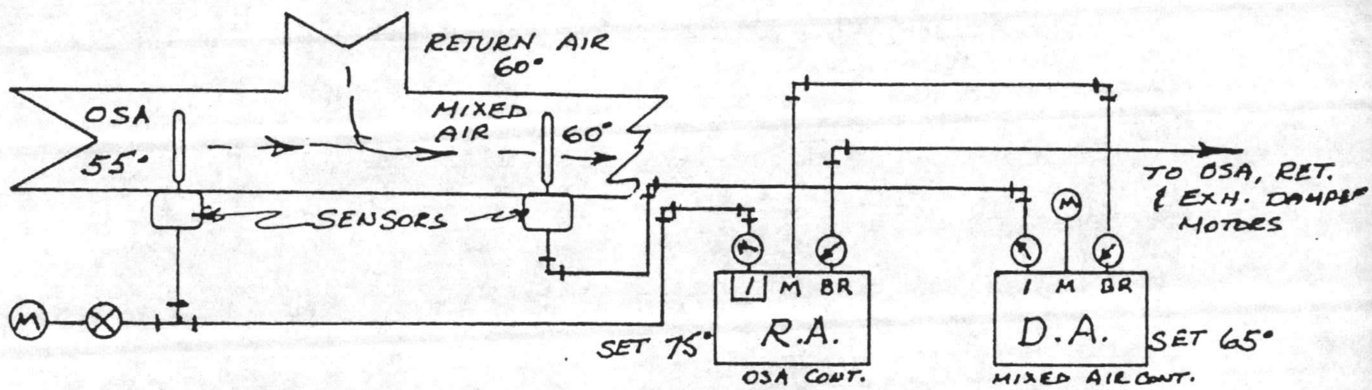
Step 5. Turn set-point dial to desired OSA set point.

You have calibrated and set the OSA controller if you have put full Ⓜ air on it from the Mixed air controller. See example:



We now have 65 degrees F. OSA, which is 10 degrees F. below the 75 degrees F. desired set-point, so our R.A. OSA controller would be putting out full 20psi to the Ⓑr or output. This means that there is 20psi going to the damper motors.

To complete the "Economizer", we need to add the "Mixed Air" controller that has a sensor in the air that is a combination of return and OSA. Example:



To calibrate the Mixed Air control, you would follow the same five steps that was used to calibrate and set up the OSA control. The only difference is that the mixed air control is D.A. instead of R.A. and the set point would be left at 65 degrees F. instead of 75 degrees F.

The "Economy" feature works like this - we have a cold building (return air at 60 degrees F.) and an OSA temperature of 55 degrees F. The temp. at the sensor for the mixed air control is 60 degrees F. or 5 degrees F. below the set-point of 65 on the mixed air controller. This means that the mixed air controller would be putting out Opsi to the OSA controller so that the N.C. OSA and EXH. dampers would be closed and the N.O. Return damper would be full open to allow the building to warm up before the OSA damper comes open.

Now, as the building warms up to, say, 65 degrees F. return air, the mixed air controller starts to put out air pressure to the Ⓜ air connection on the OSA controller. This will start to open the OSA and Exh. dampers and close down the Ret. air damper, allowing OSA to be used for cooling.

As the temp. of the OSA rises to 75 degrees F., the OSA controller starts to close down the OSA and Exh. dampers and opens the Ret. damper to keep from having to cool the warm OSA, putting an extra load on the building cooling system.

The "Economy" feature is in operation between 65 degrees F. mixed air and 75 degrees F. OSA., saving on both heating and cooling demand.

The five steps of this calibration procedure applies to all single input controllers and remote bulb thermostats. You will see how this is done in the demonstrations.

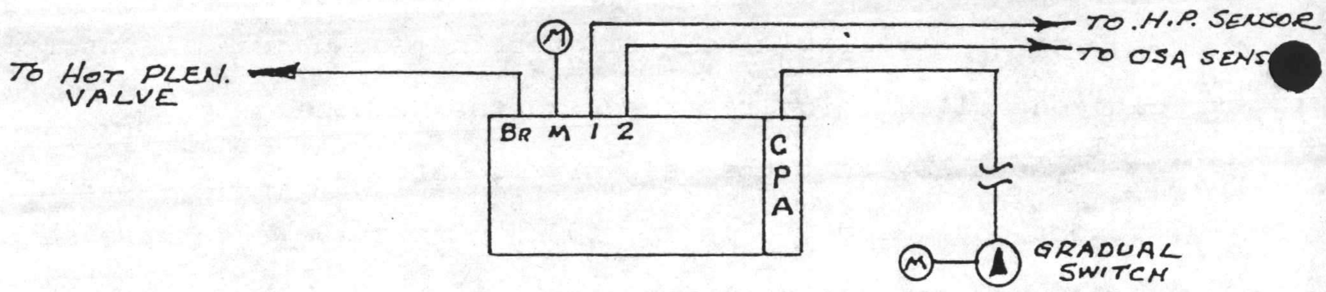
Two input controllers are different in their calibration procedure, but, here again it is necessary to consult the control drawing, if available, or transfer the set-up conditions from the old controller being replaced, to the new one.

Lets say that the defective controller has settings of 10% Proportional Band (P.B.) and 100% Authority. Set these settings on the new controller before installing it. Observe the position of the pivots and springs and set the replacement controller up exactly like the old one. The pivots and springs determine the action, either D.A. or R.A.

The "Authority" feature re-sets the set-point automatically so that as the temperature changes and the pressure change into port 2, will re-set the controller to a new control point. Changing the Authority from 100% to 200% doubles the command, or authority that the OSA (if it is connected to port 2) will have over port 1 of the controller. A typical set-up schedule or chart may look like this:

OSA		HOT PLEN.
40°	=	120°
60°	=	100°
80°	=	80°

A controller can be either a 1 port or a 2 port and have another port called the "Control Point Adjustment" (C.P.A.). This C.P.A. allows the controller to be re-set or adjusted from a remote position, so it is often called a "Remote C.P.A." This feature takes the place of someone standing by and turning the adjustment knob, or screw, to raise or lower the temp. that the controller is controlling. This is how it works:



We are controlling the Hot Plenum temperature at 120 degrees F.; we have a 40 degrees F. OSA temperature and the (Br) output from the controller is holding the hot plenum at 120 degrees F. at these conditions; - the C.P.A. Gradual Switch is on a control panel down in the Maintenance Engineers office and a tube is run up to the equipment room from the gradual switch ten floors to the C.P.A. connection on the controller. The Engineer can change the hot plenum temperature from his central panel in his office.

The "Gradual Switch" is calibrated by removing the knob, turning the shaft to read 8psi from the (Br) line, then installing the knob in center position.

The controller is set up for operation, as per schedule, and this is done with the C.P.A. gauge reading 3psi. Now the gradual switch will either raise or lower the temperature as desired, from the Engineers office.

Room (T) stats come in a great variety also, and each brand name has their own way of calibrating them. Keep in mind that it is necessary to recalibrate a room stat every time you change the "Sensitivity" setting. Also remember that a D.A. and a R.A. room stat calibrate in the same manner.

Before attempting to calibrate room (T) stats, it is necessary to have a 'Test Gauge Adapter' that goes with your particular (T) stats. These are available from the control company that sells and installs your make of stat.

There is usually a "Test Port" built into the room stat that is for the purpose of receiving the test gauge to check calibration. The video tapes will show you the (T) stat features and actual calibrating procedures.

There are again five steps to take to successfully set up room stats. They are: 1) Remove the cover and locate the test port; 2) Plug in the test gauge; 3) Read the temperature (either on the stat cover or a service thermometer); 4) Match the set-point to the temperature; and 5) Turn the calibration screw to 3psi. Thats it!

Some (T) stats do not have adjustable sensitivity and these are usually about 2-1/2psi per 1 degree F. sensitivity. The ones that can be changed have a slider or scale that helps to determine the setting. If we have a stat that changes its (Br) pressure 2psi for every 1 degree F. temperature change and we want to make it react faster, we "increase" the sensitivity. Many are adjustable from 2 to 10psi output for every 1 degree F. temperature change.

There is a term used in control work that describes a (T) stat or a controller that is too sensitive. This term is "Hunting". Hunting occurs when a controlled device, a valve or a damper, will not settle down to a stable position. It keeps searching, or hunting, for a place to stop, a control point. The best sensitivity is when a stat is very sensitive, without hunting.

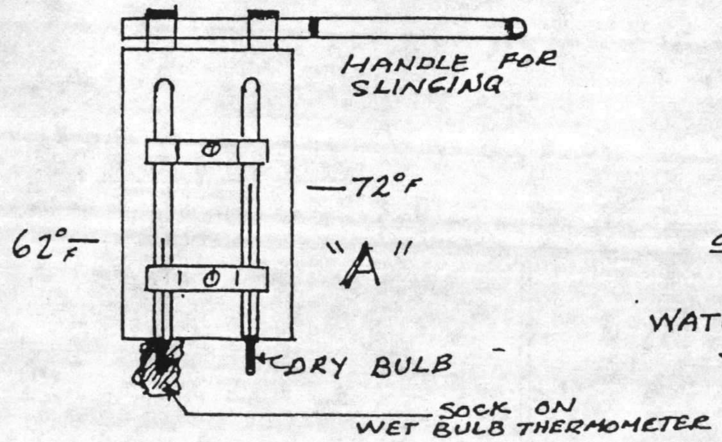
Another caution! Dont fondle a (T) stat. The heat from your hand can affect calibration, so adjust it as rapidly as possible and get away from it. When you have arrived at calibration, swing the dial or set-point indicator 10 degrees F. above calibrated point and let it settle out. Now swing the dial 10 degrees F. below the calibrated point, let it stabilize and set it back to the calibrated point and see if it stops at approximately 8psi. If it does, the job is well done. We should have mentioned that, even if the stat cover has a thermometer built into it, it is still good to check it with your digital, or accurate service thermometer. Some of the cover thermometers can be recalibrated also.

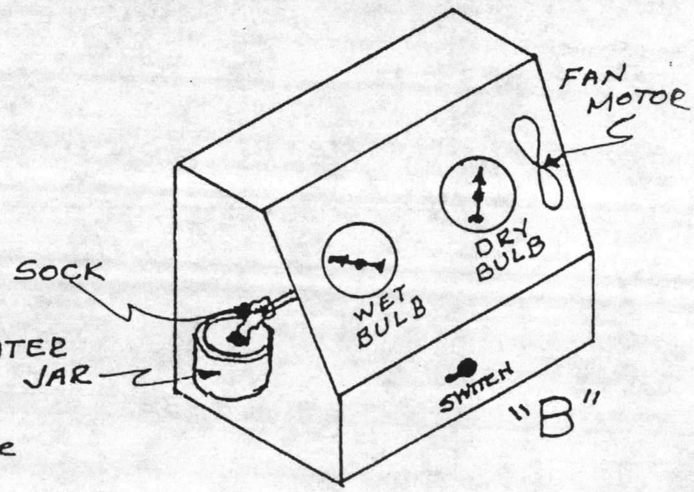
Humidistats ((H) stats) calibrate just about the same as (T) stats except that the means of measuring humidity requires two thermometers. The humidistat cover, ordinarily has larger, or more ventilation openings than (T) stat covers.

The two thermometers should have the same scale ranges for easy reading. One thermometer is called a "Dry Bulb" thermometer and the other one a "Wet Bulb" thermometer. Actually, the wet bulb thermometer is a dry bulb thermometer with a "wick" or "sock" over the bulb end which is wetted with water. To get a wet bulb reading, it is necessary to have the thermometer in moving air. The rapid evaporation of the water from the sock will give a lower temperature than the dry bulb thermometer.

When a dry bulb and a wet bulb reading is obtained, the readings are compared to give you the actual "Relative Humidity" of the space.

There are some pretty exotic instruments called "Psychrometers" and "Hygrometers" in use to find the "relative humidity" in a space. The sketches show two simple ones:

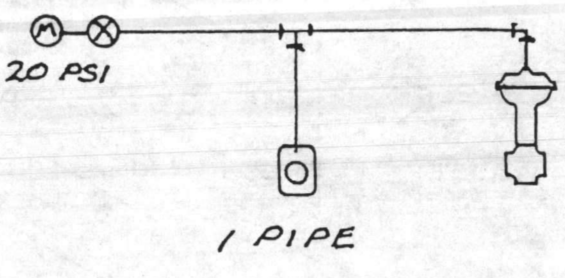


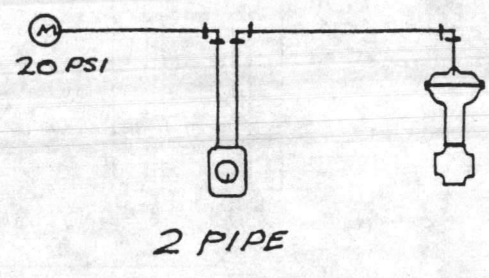


In sketch "A" the sock is wetted and the two thermometers are rotated in a swinging motion until the wet bulb reading becomes stabilized, or stops dropping. This temperature should be read very rapidly, after stopping the "slinging" motion, and the reading written down. Next, read the dry bulb reading and write it down. We now go to a chart or Relative Humidity slide rule and by lining up the two readings, we read the relative humidity. This is R.H. and reads in % R.H. After we know the % R.H., we simply line up the pointer on the humidistat, with the R.H. reading on the scale and turn the calibrating screw to 8psi and it is in calibration.

Most control companies have a Relative Humidity dial, or chart, or slide rule available for little or no charge.

There are 1 pipe and 2 pipe Ⓣ stats and Ⓗ stats. The 1 pipe requires a restricted air to the stat and the 2 pipe requires a Ⓜ air supply. The 1 pipe is much slower acting, so take this into consideration when calibrating. They still calibrate the same way. The sketches show the two kinds:





1. What is meant by "Calibration"?

____

2. What design principle is used in most "Pressure" and "Temperature" gauges?

____

3. How would you tell the difference between a pressure gauge and a temperature gauge?

____

4. How can temperature gauges be checked for accuracy?

____

5. Explain how to recalibrate a temperature gauge?

____

____

____

6. When you see a 0 to 100 degree F. temperature gauge on a control panel, what range temperature transmitter, or sensor, should it have?

____

7. Why is it important to check, or calibrate, thermometers and gauges before calibrating the controls?

____

8. What are the five steps in setting up a single input controller?

1) ____

2) ____

3) ____

4) ____

5) ____

9. What is the purpose of an "Economizer" system?

10. Before "changing out" a controller, in a control panel, what is recommended?

11. What is the difference in operation between a 1 input and a 2 input controller?

12. What does a remote "C.P.A." do?

13. Is there a difference in the manner of calibrating a D.A. stat and a R.A. stat?

14. What is necessary to do after changing the "sensitivity" of a (T) stat?

15. Why should the actual calibration of a room (T) stat be done as rapidly as possible?

16. Although (H) stats calibrate basically the same as (T) stats, how do you know where to set the pointer on a (H) stat?

17. How do you find the % R.H.?

13. Why does a 1 pipe stat react slower than a 2 pipe stat?

LETS GO ON TO THE NEXT SECTION #4-B.

At this point in the program, we should have gained experience and courage enough to want to maintain your own control system.

We are going to discuss what operations should be done and when. There are some manufacturers recommendations on the best way to keep their equipment in operation beyond the warranty period.

Service departments usually have "Service Contracts" and schedules for monthly, 3-month, or 6-month calls to tune-up a control system or go all the way through a complete calibration. The serviceman may go to his companys files and get a "Control Drawing" of each system that is in the building on his customer list. He also builds up a catalog and service manual that covers the equipment on his jobs. It is impossible to keep it all in your head, so a ready reference library can be very valuable.

The video tapes in this program also will save many hours of searching and reading, so keep them handy. You will find that as you gain more experience, you will depend on the tapes less and less. A word of <u>CAUTION</u>! Do not store the video tapes near a magnetic source, such as transformers, load centers, electric motors, etc., as the magnetic field can scramble or erase the tapes Also, keep them in the shipping cases when not in use and they will last forever.

There are commercial Service Forms available from printing suppliers, that are quite convenient, but you may want to make up your own. With the copy machines that are available, once you have the "Master Form", you can run off as many copies as you wish.

We will show you a "layout" of one that has been used successfully, and will cover the steps needed to do a good job of maintaining the complete system.

It is recommended that you start at the "air source", just as we did in the program, and proceed in an organized way through the system to the room Ⓣ stats.

We will conclude this section with a "Fold Out" control drawing and give you some hints on easy ways to read it.

One serviceman that carried his own file of control drawings, and color-coded his drawings for quick reference. He made all Ⓜ air lines red, branch lines blue, sensor lines yellow, and relay lines green, etc. Again, with the copy machines that we have today, you could copy your own control drawing and color-code it if you wish, or follow the connecting lines on through the drawing if you think it would help.

If you follow a "service procedure" in an organized way, when you get called away on another job, (and you will get called away) you will be able to pick up where you left off and continue through the system by taking it in steps. You will, no doubt, find some terms on the "Service Procedure Sheet" that you are not familiar with, these will be explained after we present the procedure sheet.

One suggestion before you start using the service procedure sheet is to recruit another man to help in identifying and labeling zone and room Ⓣ stats. This can be done with a good set of portable radios, or some means of communicating between the Ⓣ stats and the mixing dampers, or valves that they operate. One organized way to do this is to start from left to right in labeling zone dampers, and call the far left one Z1, then Z2, Z3, etc. Have a man move the Ⓣ stat down in the room, and watch to see which damper motor moves on the air handler in the equipment room. For example, if he removes the Ⓣ stat cover and turns a Ⓣ stat up 10 degrees from set-point and waits two minutes, then turns the Ⓣ stat 10 degrees below set-point and waits another two minutes, then back to set-point, the man up in the equipment room watching the dampers move can tell the man at the Ⓣ stat which zone damper moved, and they can label the zone by a sticker or mark the zone number inside the Ⓣ stat cover to match the zone marked on the damper motor.

In the case of valves being operated by room Ⓣ stats, you could hang a tag on the valve to match the Ⓣ stat marking. This operation will help in quick identification of which Ⓣ stat operates which device. Also, it will help to locate crossed zones, which we have found even after many years of operation. Crossed zones are something to look for if you are having trouble controlling some areas constantly.

Some systems are self-explanatory, such as which Ⓣ stat goes with which device, etc., so labeling is not really necessary.

You will notice that we have put two copies of the "Service Procedure Sheet" in this manual. This is so you can remove one and copy it for your records of regular service on your system. We have tried to keep it as simple as possible because we are aware of how the service engineer dislikes fooling around with a lot of paperwork. Some record is really valuable though, because it not only will insure that the service is being done, but also will spot a control or device that needs constant attention so that it can be replaced.

Service of pneumatic controls should not be a hit-or-miss proposition in any building where "creature comfort" is important. For lack of proper temperature control, we have seen leases broken and whole rental suites move out. In one building, we saw the entire third floor walk out and go home because the air conditioning controls were all fouled up.

We certainly recommend getting familiar with the operation of the back-up equipment such as chillers, boilers, pumps, etc., to better understand how to control them. The next page contains a sample "Service Procedure Sheet".

SERVICE PROCEDURE SHEET

Building ____________________ Date ________________

Equipment Room Location ____________ Engineer ____________

Air Supply:

1. Compressor cut-in pressure__________psi. Cut-out pressure_______psi
2. Air Cleaner.......Checked____ Cleaned____ Changed____
3. High Pressure relief valve......Checked____
4. Oil...............Checked____ Changed____
5. Belt..............Checked____ Adjusted____ Replaced____
6. Drained Tank____
7. Automatic Drain Valve.....Inspected____ Cleaned____
8. Air Drier.........Checked operation____
9. Pre-filter, oil & moisture......Cleaned____ Changed____
10. Main Air Pressure Relief Valve..Checked____
11. P.R.V............Checked____ Re-set____

Controls:

12. Thermometers....OSA____ Mixed Air____ Hot Plen.____
    Cold Plen.____ Dischg.____
13. Gauges-Controllers.....OSA____ Mixed Air____ H.P.____
    C.P.____ Zones____
14. Dampers Checked....OSA____ Ret. Air ____ Exh.____
15. Controller-Response and Recovery....OSA____ Mixed Air____
    H.P. ____ C.P. ____
16. Valve Packing........Hot ____ Cold ____
17. Mixing Dampers - Cycled and checked ____
18. Mixing Damper Motors.....Checked ____
19. Static Dampers and Motors.....Checked ____
20. Static Damper Controller - Response and Recovery Checked ____
21. Room (T) stats........Checked ____ Calibrated ____

Now, to explain the Service Procedure Sheet:

1) Compressor cut-in pressure. This just about explains itself because all you do is to write down the pressure that the compressor starts, or cuts-in. The same with when the compressor stops, or cuts-out. Timing the on/off cycle of the compressor is sometimes done to check for a bad leak in the system. Using a watch with a second hand, or a digital watch with the second read-out feature, write down the "start time" of the compressor, then time the running period and write down the stop time. Example: The compressor starts at 9:35 and stops at 9:39:12 seconds. You would find the running time by subtracting 9:35 from 9:39:12 like this:

```
 9:39:12
-9:35
    4:12
```

So, the "on" or running time would be 4 minutes and 12 seconds. Next to get the "off" time, start timing when the compressor shuts off and stop timing when the compressor starts. Make a note of this somewhere close by the air compressor and compare the readings with the next ones you take. This should be done once a month. The next timing will not usually be exactly the same, but any radical change means a leak to fix.

2) Air Cleaner. Inspect it on a monthly basis and clean or replace it every three months. If this is different from the manufacturers recommendation, follow his recommendation.

3) High Pressure Relief Valve. Give the ring on top of the valve a pull and allow it to blow off for a couple of seconds and release it. Make sure it seats and does not leak after checking it. This should be done once a month.

4) Oil. Check every month and change faithfully, every three months. Use the manufacturers recommended viscosity oil. Even if the oil should look perfect, the three-month change is the best insurance you could buy for your air compressor. If the compressor is in a dusty location, or there is construction going on nearby, check it often.

5) Belt check. Every month, the tension and condition of the belts should be checked. A big problem can be avoided by replacing a dried-out or worn belt before it breaks. Also, the proper belt tension is important to prevent belt and pulley wear. Check the tension half-way between the motor pulley and the compressor pulley and you should be able to depress the belt about 1/2" easily.

6) Drain Tank. Every week, open the manual drain valve on the bottom of the tank, and keep it open until all the water is drained out.

7) Automatic Drain. If the automatic drain valve has a manual button, push the button and hold it in for a few seconds to drain the trap. After releasing the button, check the end of the drain tube to be sure that the manual valve seats again. If it is leaking through, just bump the button with a few light taps and it will probably seat OK. This button should be pushed once a month and the trap checked or cleaned every six months. CAUTION! These traps are on the high pressure side of the air supply system, so close the valves to the trap and open the by-pass valve around the trap and bleed the pressure off the trap by pushing in the manual drain valve and dropping all the pressure in the trap. It can now be disassembled safely.

8) Air Drier. If this is a refrigerated air drier, feel

the small refrigeration unit to see if it is warm. If so, it is usually OK. Check the condenser fan to see if it is running. If the system uses a lot of air, there will be a big temperature difference between the "in" and "out" piping and often times the "out" pipe will sweat or have condensation on it. There is also a drain trap inside the refrigerated air drier that has to be checked and serviced.

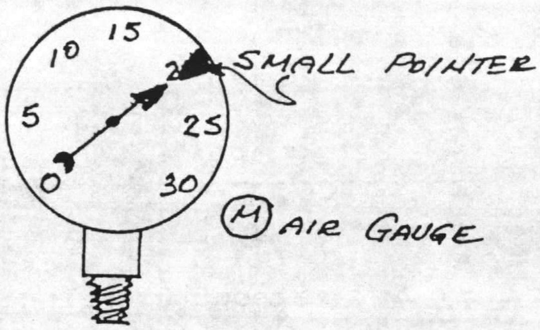
9) Pre-filter. This one can pick up oil and moisture and is the one just before the piping goes into the Pressure Reducing Valve. It usually has a "blow-down" valve on the bottom of the bowl to get rid of oil or water that has been trapped in it. This valve has to be opened by hand.

This filter contains a "media" that holds contaminants and it is according to the age and condition of the air compressor as to how often this should be changed, however it should be inspected monthly and usually changed yearly. Most of these pre-filters have transparent bowls and you can see the condition of the filter; however, it should be opened about every six months. If there are no by-pass valves around this filter, it will be necessary to drop the air off the whole system to disassemble it, so pick a time when this can be done easily.

10) Main Air Pressure Relief Valve. Check this monthly. About all there is to checking the relief valve is to pull up on the valve stem on the top, and let it blow for a couple of seconds, then release it. Make sure it seats again. It may take a slight push down on the stem to seat the valve again if the setting of the valve is real close to the Ⓜ air pressure. If it leaks out the

blow-off holes in the side of the valve, loosen the check nut and screw the adjustment down until the leak stops. Do not tighten the adjustment too much because you will loose the safety feature of the valve, just enough to make sure it seats at the (M) air pressure.

11) <u>P.R.V. Checked/Re-Set</u>. The P.R.V. requires very little service, but it should be checked by observing the leaving (M) air pressure on the gauge. It is a good idea to make a small pointer out of masking tape and stick it on the face of the gauge to indicate the (M) air pressure setting. Future checks will tell at a glance if the P.R.V. has wandered off setting or if there has been a leak develop in the system. We have made the pointer by spraying a small piece of masking tape red, and cutting it into a wedge-shape for the pointer. This is the way we put them on the gauges:



This little pointer method can be used anywhere in the system to mark a reference point on the gauges or thermometers.

About every six months, it is a good idea to move the P.R.V. setting up about 2psi from the setting and down 2psi from the setting and back to the set-point. This should be done quite rapidly to keep from upsetting the system, but it will help keep the P.R.V. alive.

12) <u>Thermometers</u>. These in OSA, Mixed Air, H.P., C.P., Dischg., etc., should be inspected on the monthly check-through

and checked for accuracy every six months on the complete service check. The "Calibration" section will help you if you need to recalibrate it.

13) <u>Gauges - Controllers</u>. A quick glance will tell if the gauges are close to calibration on the walk-through check, but they should be calibration-checked every six months and corrected if necessary.

14) <u>Dampers Checked</u>. Run the dampers through a complete cycle, open to closed to open, once a month and check for binding, sticking and travel. If service is needed, do it as soon as possible. This is about all that is needed on the six-month check also. Your building location has a lot to do with how much attention the OSA dampers especially need. If you are near the sea-coast, you know what the salt air can do to dampers, so give them a lot of attention.

15) <u>Controller - Response and Recovery</u>. These terms "Response and Recovery" may be new to you, but it explains the way to check a controller without changing its set-point. First, lets take the example of a single input controller that is controlling at 8psi branch pressure. If it is a balance-beam type of controller, like Honeywell, you can move the balance beam by lifting up or pressing down on it manually to bleed off all branch pressure. When you release it, it should "recover" to the original 8psi if you do this rapidly before the controlled condition changes temperature. The "Response" is checked by unscrewing the gauge in #1 port to drop the air pressure to this port only slightly; if

the branch pressure changes as the port pressure changes in #1 port, the controller is "responding". The same idea can be used on all controllers whether they be one, two, or two with C.P.A. for the third port. If there is no mechanical means of bleeding off the air, the input gauges in any one of the ports can be unscrewed to change the branch pressure or check the "Response".

The tape demonstrations will show this "Response and Recovery" check for different manufacturers controllers. The reason for this check is to determine if the controller is dying of old age or is still active.

16) Valve Packing. This is a visual check, and a quick look at the point where the valve stem enters the valve body will tell you if the packing is OK. Look at it every month.

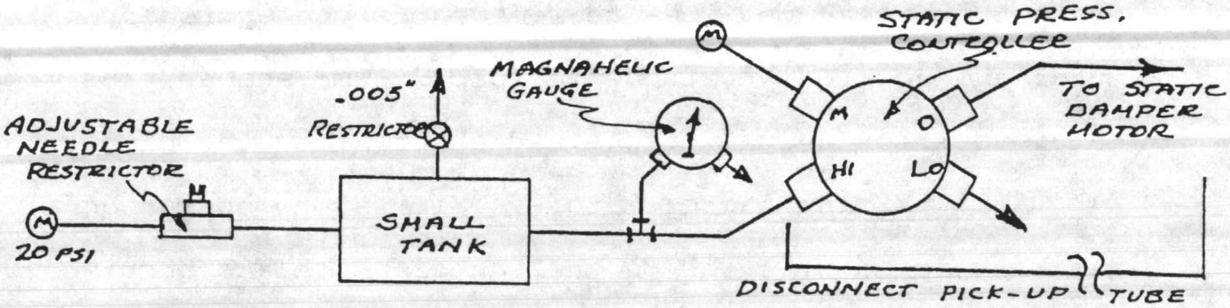
17) Mixing Dampers. These should be cycled, or moved through their complete stroke, once a month to check for binding, sticking, etc. It is not usually necessary to unlink these dampers from the motors unless a problem is suspected. However, every six months, it is a good idea to remove the connection from the damper motor and hook on your squeeze bulb. Pump enough pressure on the motor to allow a full stroke and observe how the damper travels.

18) Mixing Damper Motors. Similar to operation #17, these can be checked by tying on the squeeze bulb and pumping 10psi on the damper motor, and watching to see if it holds 10psi for a period of time (usually about one minute is all that is necessary). This is a diaphram check on the damper motor.

19) Static Dampers and Motors. Check these the same way as other dampers and motors, but be sure that the blower is off when you run this once-a-month check.

20) Static Damper Controller. Response and recovery on this controller can be done by just loosening the fitting that connects to the static pressure controller from the static "pick-up" tube. The controller output should change as the static pressure changes, by loosening the fitting. This checks the "Response" of the controller. By tightening the fitting again, it should "recover" and start controlling again. Obviously, this check has to be done with the blower on, or with a means of simulating a static condition changing.

On one job, we had 32 static pressure controllers and their damper motors to check out. We did this without the blowers being turned on by reading the designed static pressure to be maintained and simulating this condition by building another gizmo to simulate the duct static pressure. This is what we did:



The parts used were: 1) adjustable restrictor; 2) small tank (we made one from a pop can); 3) magnehelic gauge, with the proper range scale. Simple, but it worked fine.

21) Room (T) stats. The stability and accuracy of the pneumatic room thermostat is truly amazing. A case in point is,

at one time a pneumatic thermostat was found that had been untouched for five years because another wall had been built about three feet in front of the wall that this Ⓣ stat was mounted on and it was boxed in. During remodeling, the front wall was torn down and the old Ⓣ stat was checked with a test gauge. It was found to be in perfect calibration, although it was very dusty.

Unless you have people in your building who have screwdrivers, hairpins, long fingernails, etc., who like to play with the thermostats, they hang in there very good. If there is a clean and dry Ⓜ air to the stats, very little problem is encountered. One thing that often happens is when someone "attacks" a Ⓣ stat who does not know what he is doing, he will either force it against the stops, either high or low temperature reading, or bend something that destroys the calibration so that it is no longer able to control at the set-point.

You, no doubt, have "spot" or "emergency calls" periodically, but there is no need to go all the way through the Ⓣ stats more than every six months.

If you have an area in the building that has several Ⓣ stats, and the whole area is over-heated or over-cooled, dont condemn the room Ⓣ stats right away. Go to the source, the air handler, and check the discharge temperature for that space. Usually, the problem is in the equipment room.

To recalibrate room Ⓣ stats, it is a good idea to remove the first cover and install your "test gauge". Then leave that Ⓣ stat and remove the covers of a few more, while the first one is stabilizing. If you have a lot of Ⓣ stats on one floor, it is an advantage to have two test gauges and leap-frog from stat to stat. Do the adjusting rapidly and get away from the stat so that the heat from your hands do not give you a false reading or sensing.

We went through the calibration procedure in the section on "Thermostats" and also the tape, but a quick, simple review might be: Step #1) Remove the cover and install the test gauge; 2) Read the temperature on the thermometer and match the temperature and the set-point on the dial; 3) Check the test gauge and set the pressure at 8psi; 4) Remove the test gauge and install the cover, and thats it!

If you wish to check response and recovery, before you remove the test gauge, blow a hot breath on the Ⓣ stat and watch the response. Then back away from the Ⓣ stat and blow a cooler breath on it and watch the recovery as it attempts to return to the original output. It may not recover all the way, but it will be close.

It is time now to go over the "Control Drawing" fold-out and follow the lines through from Ⓜ air to controlled device, valves, dampers, etc.

The Ⓜ air enters the control panel on the left side and is connected into the mixed air controller, the hot plenum, and cold plenum controllers. Also it goes out in the space to the room Ⓣ stats.

Take special notice and see that before the OSA controller can operate, the dampers, it must get its Ⓜ air from the branch of the mixed air controller. Comparing the OSA and the mixed air controller, we find the #1 port on the OSA controller is blocked, like this: [1] . The reason for this is so that the temperature gauge in port [1] can read OSA temperature at all times by using a "restrictor" in the line to the OSA sensor, that (M) air is connected into. If this port were not blocked, and we tried to use the restrictor that is inside the controller, there would be times when there is no (M) air to the OSA controller, the OSA temperature gauge would not read the temperature.

In the controller, under the #1 port, there is a restrictor built-in that operates the sensor from the (M) air to the controller. When a port is "blocked", the internal restrictor is removed, and a "blank" is put in its place. When this is done, an outside restrictor is needed from the (M) air.

Starting left to right, we find the mixed air controller is calibrated and set at 65 degrees F. A quick look at the temperature gauge in port #1 of the mixed air controller tells us that the temperature at the mixed air sensor is less than 65 degrees F. so there is no air leaving the controller because it is D.A. The OSA controller will not operate under this condition, because we do not have (M) air from the mixed air controller.

To check the damper operation under this condition, turn the set-point on the mixed air controller down below the temperature on the gauge in port #1. Now, go to the OSA controller and read the OSA temperature on the gauge in port #1. If the OSA temperature is below 75 degrees F., the dampers will operate. This will check damper operation. If we now match the set-point on the controller dial with the temperature gauge reading on the OSA controller, the (Br) pressure to the damper motors should read approximately 8psi, if the controller is in calibration. If not, correct it. Set the OSA controller back to 75 degrees F. set-point.

Next, go to the mixed air controller and check the calibration by setting the set-point to match the temperature reading on the temperature gauge in port #1. If it reads 8psi (Br) pressure, it is in calibration. If not, correct it. Set the mixed air controller set-point back to 65 degrees F. set-point, and we have checked damper operation for the OSA, Exh. and Ret. dampers.

The "Main Air" gauge on the panel should read a constant 18 to 20psi.

Next, go to the "Hot Water Controller" and read the temperature on the temperature gauge that is in port #1. If it is above the set-point of 120 degrees F., there will be no air to the H.W. valve, because it is a R.A. controller. Follow the water piping and you will see that with no air on the valve, the water will be entering the N.O. port and leaving through the C. port, by-passing the heating coil. If the temperature is below-setpoint, there will be air on the H.W. valve, closing the N.O. port and opening the N.C. port to C. on the valve, allowing water to flow through the coil to heat the hot plenum.

Cycle the heating valve by setting the controller above, and below, the temperature gauge reading. Check calibration by matching temperature and set-point and reading 7-1/2psi (half-way between 5 and 10psi, the valve spring range). Correct the calibration, if necessary, and leave it set at 120 degrees F.

The last "primary controller" in our control panel, is the "Chilled Water Control". If the temperature on the temperature gauge in port #1 is above 55 degrees F., there will be air on the (Br) line to the C.W. valve, because the controller is D.A., and water will be flowing from the chilled water supply (C.W.S.) through the coil, to the N.C. port and out the C. port to the chilled water return (C.W.R.), we will be cooling the cold plenum. Match the temperature and set-point to check calibration, and if the (Br) pressure goes to 7-1/2psi, it is in calibration. If not, correct it, set the C.W. controller at 55 degrees F., and we have checked out all primary controls for building 10 - AC - 4.

Progress on to the Room (T) stats and mixing dampers. It is usually best to use the squeeze bulb and pump the damper motors, because the (T) stat is a long way away. If you have help, you can operate them from the (T) stat location. Check the "travel" and "freedom of operation" of the mixing dampers. Do this in an organized way by starting with #1 Lobby, #2 Room 101, #3 Room 102, etc., and work on through all the dampers.

We finally arrive at the last device on our control drawing, the room (T) stat. On the drawing, you read that it is D.A. and the set-point is 72 degrees F. You check the thermometer and find the space to be 72 degrees F. - right on. Put in the "test gauge" and you should be reading 6psi approximately. The reason for this gauge pressure is that you have damper motors with 4 to 8psi springs and 6psi is right in between 4 and 8. Now, turn the stat up a few degrees and watch the gauge pressure drop (because it is D.A.) and when the pressure stops dropping, set the stat a few degrees below 72 degrees F. and watch the gauge pressure rise on above 6psi. When it stops moving, reset the dial to 72 degrees F. If it stops at 6psi, plus or minus 2psi, it is in calibration. If not, correct it.

Congratulations! You have just completed checking and re-calibrating AC - 4 system for building 10.

This is a very basic system drawing, as you can appreciate, but if you thoroughly understand the operation of the controls on this control drawing, you should not hesitate to set up your own system. If additional devices such as relays, E.P. valves, etc., are involved in your system, just follow the lines through and you will see what is supposed to happen. When you view tape #4-B, have the control drawing in front of you and follow the discussion, this will help also in reading a control drawing.

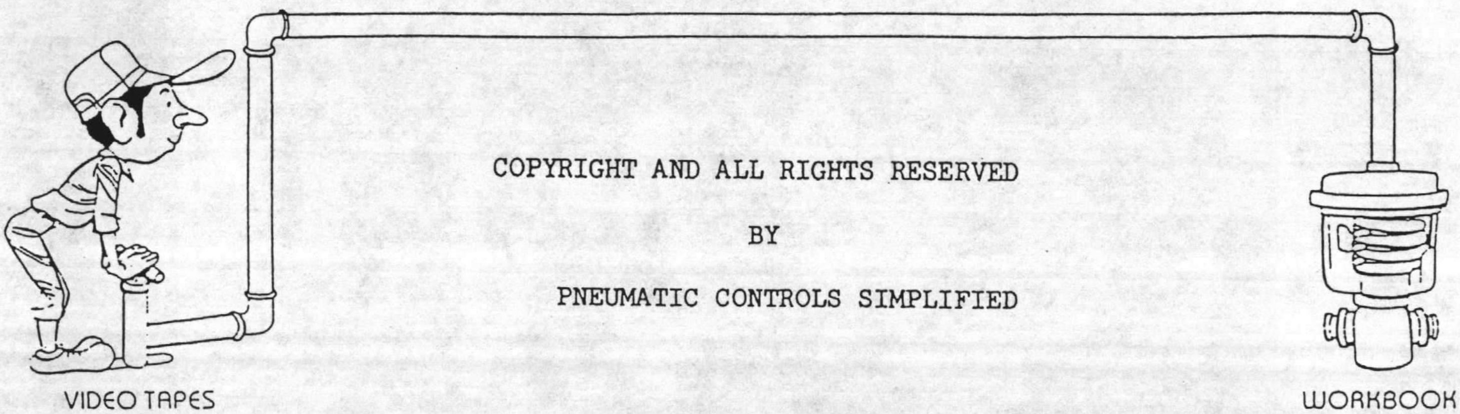
Pneumatic Controls are truly an interesting and fascinating field to work in and we wish you every success with your own system. Keep in mind that the only thing pneumatic controls accomplish is to either put air on to a device or remove air from it. Relax and enjoy watching your efforts rewarded as the system you work on responds to the adjustments you have made and functions as it was designed to.

As we mentioned in the beginning of this program, we have purposely left out the engineering and design of the controls, because we do not feel that they are necessary to service and set up a control system. If you wish to go on from here, there are a lot of sources of information available to you on design and engineering.

Thanks for being with us through this program, and we are sorry that we do not give out diplomas on completion of this course. However, if you have now learned to work with pneumatic controls, you may well see a change in your paycheck. The best to you!

Sincerely,

The Instructors of
PNEUMATIC CONTROLS SIMPLIFIED



VIDEO TAPES

Pneumatic Controls Simplified Training Program

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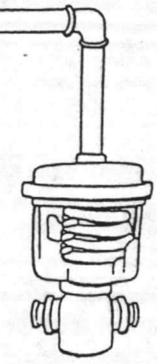
Spring Valley, CA 92077
(619) 464-1516



WORKBOOK

WRITTEN REVIEW

ANSWERS

FOR

SECTIONS No 1-A THRU 4-A

IN

WORKBOOK

WRITTEN REVIEW

Air Supply Section on Tape #1-A

Note: Please do not take this written review until __after__ you have viewed tape #1-A.

1. What 2 purposes does the air intake filter serve?

Clean the air entering air compressor and Take out abrasives

2. Explain the principle of Pneumatics.

Air Pressure overcoming spring pressure to cause motion

3. How would you identify the Suction, or intake valve from the Discharge valve on the air compressor?

SUCTION Valve is next to intake DISCHARGE Valve is next to discharge line.

4. What two purposes does the check valve in the discharge line from the compressor to the storage tank serve?

Prevents air leaking by Dischg. valves and Allows compr. to start unloaded

5. To Unload a compressor means what and why is this necessary?

To bleed off high pressure in the discharge line - Necessary to allow the compressor to start easy, saves wear on Drives and also Electricity.

6. How do you stop a compressor from pumping more air than is needed?

Pressure Switch stops the motor

7. When a pressure switch is adjusted to maintain a 60 to 80 psi in the storage tank, what is the range and what is the differential of the switch?

Range 60 to 80 psi Differential 20 psi

8. What do the letters P.R.V. stand for?

Pressure REGULATING Valve

9. There are two Pressure Relief Valves in air supply systems; where are they located?

High Pressure side and Low Pressure side

10. What are the greatest enemies of penumatic control systems?

OIL, DIRT and MOISTURE

11. When using building or "Plant" air for pneumatic controls, what is it necessary to add before the air enters the P.R.V.?

A "Blow-Down" filter or an Automatic DRAIN Valve

12. Dessicant drying systems would be used on which system?

A. A continuously running Continuously or

B. Compressor that cycles ____________

13. An "Automatic Drain Trap" is used to do what?

To eliminate Moisture from the Control Air

14. What is the most effective way to separate moisture from control air?

With a Refrigerated Drier

15. Why would a refrigerated drier be better than a chilled water drier?

Chilled water may be turned off at night or seasonally

16. When does the air become (M) main air or (S) supply air - after it leaves what device?

Pressure Regulating Valve (PRV)

17. Why is it good to "Valve Off" any added device to a penumatic piping system?

For servicing - without shutting down

18. In a high-rise building, say, 22 stories, how would you maintain a 20psi (M) on all floors?

Run a High pressure line to a 2nd PRV to split the (M) air.

LETS GO ON TO THE NEXT SECTION #1-B.

TAPE #1-B

Note: Please do not take this written review until after you have viewed tape #1-B.

1. Where do we usually find Primary controls in an air-conditioning system?

On Control Panels - usually in the equipment rooms

2. What two terms are very important in the Master/Sub-master control relationship?

DIRECT ACTING (DA) and REVERSE ACTING (RA)

3. Direct Acting means Output press. increases on Temp. increase
Reverse Acting means Output press. Decreases on Temp. Increase

4. A Normally Open Valve (N.O.) is a valve that is Open with no air on it.

A Normally Closed Valve (N.C.) is a vlave that is Closed Tight with no air on it.

5. There are two reasons why a Master stat in OSA and a sub-master stat is used in heating. What are the two reasons?

Economy - saves Energy and Allows closer control of Bldg. Temp.

6. Even though the motion created by a capillary tube may be only in thousandths of an inch, how can this motion be used to actuate a control?

By Levers, Pivots and Fulcrums

7. How is it possible to determine if a control is direct or reverse acting?

By observing the Pressure change when the Temperature changes

8. If a sub-master control is designated on the control drawing D.A./R.R., what does this mean?

Control is Direct Acting - with Reverse readjustment

9. From a control drawing, how do you know how to set up a Master/sub-master combination?

Simulate conditions on the control drawing, or make your own charts

10. What is meant by set point? Numbers under the pointer on dial

11. Some control companies use the term "Transmitter" and others use the term "Sensor". If this device has a span of 100 degrees and operates between the pressures of 3 to 15psi, what is the relationship of pressure to temp?

Low End = 3psi High End = 15psi Example: 0° = 3psi 100° = 15 psi

12. Even though there are some Master/sub-master controls in use today, what is the more modern equipment that does the same thing?

A Sensor connected to a Controller

13. What does "Authority" mean?

The Command one Sensor has over another Sensor to a Controller

14. If you have to replace a controller and no control drawing is available, what is recommended?

Set the same settings on the new controller as the old defective one

15. How do you keep plastic lines, that are all the same color, from getting mixed up when changing a controller?

Label or Tag them BEFORE! disconnecting them from controls

16. Mis-match can occur if you use a variety of manufacturers controls, called a "Heinz" system, so what is recommended?

Stay with the same make of control if possible

17. Still under this #1-B heading, we have P.E. switches and E.P. valves. What does each designation stand for?

P.E. Pneumatic operates the Electric (switches)
E.P. Electric operates the Pneumatic (valves)

18. What does a P.E. switch do?

Turns On and Off Electrical devices

19. What does a E.P. valve do?

Opens or closes Electrically to allow air to pass

20. Can you think of another name for an E.P. valve?

Solenoid Air Valve (SAV)

21. If you have to replace the pull in coil in an E.P. valve, what caution must be taken?

USE SAME VOLTAGE COIL

LETS GO ON TO THE NEXT SECTION #2-A.

WRITTEN REVIEW - CAPILLARY TUBES AND SENSORS
TAPE #2-A

Note: Please do not take this written review until after you have viewed tape #2-A.

1. When replacing a capillary tube on a control, having a cap. tube, why is a shorter cap. tube better?

   Faster response to temperature changes

2. How do you detect a capillary tube that is going bad?

   It Drifts - will not hold set-point on the control

3. What is the difference between a "Compensated" and a "Non-compensated" cap. tube?

   "Compensated" - Bulb only affected by temp. change. "Non-Compensated" - Bulb & tube affected.

4. Where would a "compensated" cap. tube work better?

   If capillary tube passes thru differing temperatures

5. What is an "Averaging" cap. tube?

   A capillary tube that senses over its entire length. Usually has a very long sensing element.

6. Where would an averaging cap. tube work better than a short bulb type?

   On the leaving side of a Heating or Cooling coil.

7. A temperature transmitter, or sensor, has a cap. tube. Why must the cap. tube range, or span, match the span of the sensor?

   The output will not be linear if they are mis-matched

8. What is the main difference between a temperature sensor and a humidity sensor?

   The actual sensing element

9. How does a "Bi-metal" thermostat element work?

   "Bi-Metal" will bend or warp on a temp. change

10. Name some of the "membranes" used to sense a change in humidity.

    Wood, Hair, Nylon or some plastics etc.

    contracts or expands on a change in Humidity

11. "Rod and tube" sensors are in wide use in pneumatic control systems. When would you use a long rod sensor?

Outside air sensing or inside a duct

When would you use a short rod sensor?

In a well inside a pipe or small areas

12. What is the difference between a "One pipe" and a "Two pipe" transmitter or sensor?

"Two-pipe" requires a (M) air and "One-pipe" requires a restrictor

13. When you plan to go through a complete calibration of the "Primary" controls of a pneumatic control system, where is it best to start?

Start at the thermometers or temperature gauges FIRST!

14. Explain why you would start at this point first.

It is not possible to come out with an accurate calibration when the temperature indicating thermometers are not accurate.

LETS GO ON TO THE NEXT SECTION #2-B.

WRITTEN REVIEW - DAMPER OPERATORS
TAPE #2-B

Note: Please do not take this written review until after you have viewed Tape #2-B.

1. Name as many places as you remember where "Damper Motors" are used in air conditioning systems?

   Outside air dampers

   Return air dampers

   Mixing Dampers

   Static Dampers etc.

2. Are OSA dampers usually Normally Open (N.O.) or Normally Closed (N.C.)?

   Usually N.C. - Normally closed (N.C.)

3. If you wanted an OSA damper to open fully when the blower fan starts, what device would you use to accomplish this?

   An E.P. valve electrically connected to the motor start circuit

4. Are return air dampers usually N.O. or N.C.?

   Usually N.O.- Normally open (N.O.) not always

5. What does a "Face and By-pass" damper do?

   Passes air through a coil-Face or passes air around the coil-By-pass

6. What do "Mixing" dampers do?

   Mix the return and outside air

7. Why are "Static" dampers necessary in a double duct or extended plenum system?

   To control internal pressure inside ducts when downstream dampers open or close. they maintain constant static

8. What are the basic parts of a Piston Damper Motor (P.D.M.)?

   Housing — Spring

   Diaphram — Shaft

9. How would you check the diaphram in a P.D.M. without taking the motor apart?

Connect a "Squeeze bulb" to it and see if it holds pressure

10. What determines when a P.D.M. shaft starts moving and when it stops moving?

Spring range

11. What does it mean when we say that OSA, Return and Exhaust damper motors are "matched"?

They all have the same spring range

12. How would you explain what it means to "Sequence" damper operation?

One damper motor starts after another motor has traveled full stroke

13. A damper that travels from full-closed to full-open travels how many degrees?

Usually 90°

14. If you have a "Crank Arm" that is not adjustable and is being driven by a number 4 P.D.M., what number crank arm should be used?

Use a No. 4 crank arm - match it to the damper motor

15. The "Slotted" crank arm can be used to change the travel of a damper, so what effect would be accomplished by moving the "Ball Joint" from close to the damper shaft end to the outer end of the crank arm?

Shorten the travel

16. How would you know when you have a good adjustment of P.D.M. linkage to a damper?

When it travels the full stroke without strain

LETS GO ON TO THE NEXT SECTION #3-A

Note: Please do not take written review until after you have viewed Tape #3-A.

1. What are the two main parts of a pneumatic valve?

Body and Operator

2. How do you tell the difference between a two-way and a three-way valve?

The number of connections: 2 - way has 2 and 3 - way has 3

3. Explain what is meant by a:

N.O. valve Open with no control air to the operator

N.C. valve Closed with no control air to the operator

4. When replacing a defective valve, what "rating" should you look for?

The C.V. Factor.

5. If you suspect that the diaphram in a valve operator is leaking, how would you check it?

Connect a "Squeeze bulb" to the operator and see if it holds pressure

6. In our sketches, we progressively built a valve top and we determined what usually failed or went wrong with this operator. Do you recall the main problem?

Usually a bad diaphram

7. What is a "Butterfly" valve?

A valve that is a flat round disc that fits inside a pipe.

8. When would a valve with a "Plug" be preferred over one with a "Disc"?

When closer flow control is necessary

9. If no arrow indicating flow can be found on a two-way valve body, how would you know which is "in" and which is "out"?

"IN" is the supply under the seat & "OUT" is over the seat

10. What is the difference between a 3-way By-pass valve and a three-way diverting valve?

The By-pass valve has 2 connections "IN" and 1 connection "OUT"

Diverting valve 1 connection "IN" and 2 connections "OUT"

11. What is especially important to look for or observe before removing a three-way valve from a water system?

The way it is piped into the water system

12. How do you test, or check, a pneumatic valve for positive shut-off before removing it from the lines?

By checking the air temperature entering and leaving the coil

13. When you are repacking a valve, what type packing would you use?

If possible, use the packing the valve was designed with

14. Why would you not use just any grease to lubricate packing or packing rings?

It may not have the temperature rating of the regular grease.

15. Explain what it means to "sequence" two valves?

To have one open or close before the other one starts moving

16. Do you recall what valve "By-pass" or "Dead band" using 2-3 way valves means?

When one valve is on by-pass brfore the other one opens

17. Water piping can be confusing when we are trying to figure out the way they are piped into the system. What will help us to understand the reason why they are piped a certain way?

Follow the flow from supply to return and make your own sketches of the piping arrangement. also note the action of the controller

LETS GO ON TO THE NEXT SECTION #3-B.

NOTE: Please do not take this written review until after you have viewed Tape #3-3.

1. Explain why this pneumatic device is called a "Relay"?

It passes, or "Relays" air from one port to another

2. When a 1psi change in input, or "Pilot" signal, causes a 1psi change in "Output", what is the "Ratio" rating of the relay?

Ratio is 1 to 1 or 1:1 ratio

3. What needs to be added to a 1:1 ratio relay to make it useful?

(M) Main air or supply air

4. Name the four terms used to designate relay action?

1) Direct Acting 2) Reverse Acting

3) Proportional Acting 4) 2 Position or Snap Acting

5. When the output increases gradually as the input pressure is increased, what action does the relay have?

Proportional or Modulating

6. When the output increases from 0psi to full (M) air pressure, on a slight increase in input pressure, it is called a 2 Position or Snap Acting relay.

7. State how you would use your "squeeze bulb" to check a relay for proper operation?

Connect the "Squeeze bulb" to port "P" and read the output from "O"

8. What would a "Minimum Position" relay be used for?

To prevent a damper or valve from going fully closed

9. "Selector" relays can select, or choose, a signal and send it on to the output. If you have a selector relay receiving 5, 8, 10, and 15psi signals, and it is a Hi/Lo selector, what pressure will be coming out of the two ports?

H port pressure is 15psi L port pressure is 5psi

10. If you have a 10 input selector and only 8 signals coming into it, what is usually necessary to make it work as a Hi/Lo selector?

Tee the remaining two ports into any other lines into the relay

Explain why this is so?

The "L" output would always be 0psi if any ports were left open

11. What is the "key" to finding the output of a "Reversing" relay?

20psi (M) air pressure minus the pilot pressure

12. Using this "key", if we have a 20psi (M) air and a 10psi input signal, what is the output pressure of a reversing relay?

20psi (M) minus 10psi input = 10psi output

13. Figure out the output pressure from an "Averaging" relay that has a 10psi signal into 1 port and a 5psi signal into the second port?

10psi plus 5psi = 15psi divided by 2 = $7\frac{1}{2}$psi output pressure.

14. What does the "switch" line do to a "Switching" relay?

Causes the relay to switch from port to port

15. Why would it be best to check the control drawing before trying to adjust a "Multi-purpose" relay?

They can be connected many different ways

16. What is the purpose of a "Pilot Positioning" relay?

To "Boost" the signal from weak to strong

17. Explain the reason why an "Air Motion" relay would be used between a (H) stat and a humidifier valve?

To close a humidifier valve when the blower is turned off

18. What repairs can be made on relays?

Some rebuild kits are available. Usually the input filters can be replaced

LETS GO ON TO THE NEXT SECTION #4-A

1. What is meant by "Calibration"?

To bring everything into relation

2. What design principle is used in most "Pressure" and "Temperature" gauges?

The Bourden Tube Principal

3. How would you tell the difference between a pressure gauge and a temperature gauge?

Observe the dial or scale reading. Inside may be the same

4. How can temperature gauges be checked for accuracy?

With an accurate thermometer at the bulb location.

5. Explain how to recalibrate a temperature gauge?

Hook-up a "Squeeze" bulb to the gauge and pump 9psi into it. The pointer should read mid-scale. If not, readjust the pointer to read exactly mid-scale. The gauge is now in calibration.

6. When you see a 0 to 100 degree F. temperature gauge on a control panel, what range temperature transmitter, or sensor, should it have?

0° to 100°

7. Why is it important to check, or calibrate, thermometers and gauges <u>before</u> calibrating the controls?

To insure an accurate calibration job

8. What are the five steps in setting up a single input controller?

1) Read the temperature at the sensor
2) Read the set-point on the dial or scale
3) Match the two two readings
4) Adjust the controller to 8psi output
5) Set the controller to the desired temperature

9. What is the purpose of an "Economizer" system?

1. To save money. 2. To get closer control in air cond. spaces

10. Before "changing out" a controller, in a control panel, what is recommended?

Make sure there are no leaks in the lines or diaphrams

11. What is the difference in operation between a 1 input and a 2 input controller?

1 Input requires only one sensor to re-set the controller. 2 Input-2

12. What does a remote "C.P.A." do?

Allows the controller to be re-set from a remote location

13. Is there a difference in the manner of calibrating a D.A. stat and a R.A. stat?

NO! _ They calibrate the same

14. What is necessary to do after changing the "sensitivity" of a (T) stat?

To re-check the calibration. Usually necessary to re-calibrate.

15. Why should the actual calibration of a room (T) stat be done as rapidly as possible?

to prevent body heat from affecting the sensing element

16. Although (H) stats calibrate basically the same as (T) stats, how do you know where to set the pointer on a (H) stat?

Find the correct %Relative Humidity at the stat location and move the set-point dial to that R.H. Calibrate, set desired R.H.

17. How do you find the % R.H.?

Read the "Dry" bulb and "Wet" bulb temps. and find the R.H. on a chart

18. Why does a 1 pipe stat react slower than a 2 pipe stat?

Air supply to a 1 pipe thermostat is through a restrictor.

LETS GO ON TO THE NEXT SECTION #4-B.